

**AGRO-TECHNIQUES FOR SESAME (*Sesamum indicum* L.)  
UNDER PARTIAL SHADE OF COCONUT IN  
SOUTHERN LATERITES**

*by*

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**(2020-21-031)**

**THESIS**

**Submitted in partial fulfilment of the requirements for the degree  
of**

**DOCTOR OF PHILOSOPHY IN AGRICULTURE**

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**DEPARTMENT OF AGRONOMY  
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KERALA, INDIA  
2024**

## DECLARATION

I, hereby declare that this thesis "AGRO-TECHNIQUES FOR SESAME (*Sesamum indicum* L.) UNDER PARTIAL SHADE OF COCONUT IN SOUTHERN LATERITES" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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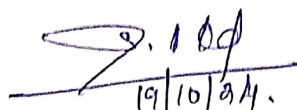
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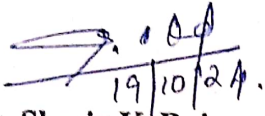
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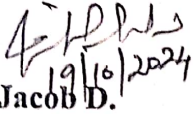
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## **TABLE OF CONTENTS**

<b>CHAPTER NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
1.	INTRODUCTION	1-4
2.	REVIEW OF LITERATURE	5-28
3.	MATERIALS AND METHODS	29-49
4.	RESULTS	50-163
5.	DISCUSSION	164-194
6.	SUMMARY	195-201
7.	REFERENCES	202-235
	APPENDICES	
	ABSTRACT	

## LIST OF TABLES

Table No.	Title	Page No.
1	Physico-chemical properties of soil of the experimental site	31
2	Technical specifications of seed cum fertilizer drill	35
3	Characteristics of sesame varieties chosen for the study	38
4	Standard methods adopted for the analysis of elements	46
5	Methods for plant analysis	46
6a	Plant height at 20 DAS and 40 DAS, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, cm	53
6b	Plant height at 60 DAS and harvest, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, cm	54
7a	Number of leaves at 20 DAS and 40 DAS, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23	55
7b	Number of leaves at 60 DAS and harvest, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23	56
8a	Number of branches at 20 DAS and 40 DAS, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23	57
8a	Number of branches at 60 DAS and harvest, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23	58
9a	Dry matter production at 20 DAS and 40 DAS, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, g per plant	59
9b	Dry matter production at 60 DAS and harvest, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, g per plant	60
10a	Leaf area index at 20 DAS, 40 DAS and 60 DAS, as influenced by nutrient levels during <i>Rabi</i> 2021-22	63
10b	Leaf area index at 20 DAS, 40 DAS and 60 DAS as influenced by nutrient levels during <i>Rabi</i> 2022-23	64
11a	Total chlorophyll content at 20 DAS, 40 DAS and 60 DAS as influenced by nutrient levels during <i>Rabi</i> 2021-22, mg g <sup>-1</sup> fresh weight	65

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
11b	Total chlorophyll content at 20 DAS, 40 DAS and 60 DAS as influenced by nutrient levels during <i>Rabi</i> 2022-23, mg g <sup>-1</sup> fresh weight	66
12a	Crop growth rate as influenced by nutrient levels during <i>Rabi</i> 2021-22, g m <sup>-2</sup> d <sup>-1</sup>	67
12b	Crop growth rate as influenced by nutrient levels during <i>Rabi</i> 2022-23, g m <sup>-2</sup> d <sup>-1</sup>	68
13a	Relative growth rate as influenced by nutrient levels during <i>Rabi</i> 2021-22, g g <sup>-1</sup> d <sup>-1</sup>	69
13b	Relative growth rate as influenced by nutrient levels during <i>Rabi</i> 2022-23, g g <sup>-1</sup> d <sup>-1</sup>	70
14	Days to 50 per cent flowering and number of capsules per plant as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23	74
15	Number of seeds per capsule and 100 seed weight, as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23	75
16	Seed yield and haulm yield per plant as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, g	76
17	Seed yield and haulm yield as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, kg ha <sup>-1</sup>	77
18	Central composite design with coded values of independent variables and experimental result of response variables during <i>Rabi</i> 2021-22	78
19	Response surface second order regression analysis during <i>Rabi</i> 2021-22	79
20	ANOVA for the fit of experimental data to response surface model during <i>Rabi</i> 2021-22	80
21	Canonical analysis to determine the optimum N, P and K for sesame in Southern Laterites during <i>Rabi</i> 2021-22	80
21a	Optimum N, P and K levels during <i>Rabi</i> 2021-22	80
22	Central composite design with coded values of independent variables and experimental result of response variables during <i>Rabi</i> 2022-23	81
22a	Response surface second order regression analysis during <i>Rabi</i> 2022-23	82
23	ANOVA for the fit of experimental data to response surface model, during <i>Rabi</i> 2022-23	83
24	Canonical analysis to determine the optimum N, P and K for sesame in Southern Laterites during <i>Rabi</i> 2022-23	83

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
24a	Optimum N, P and K level during <i>Rabi</i> 2022-23	83
25	Harvest index as influenced by nutrient levels during <i>Rabi</i> 2021-22 and <i>Rabi</i> 2022-23	84
26	Oil and crude protein content in sesame seeds as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, %	87
27	Phosphorus and calcium content in sesame seeds as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, %	88
28	Magnesium and iron content as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, %	89
29	Zinc content as influenced by nutrient levels during <i>Rabi</i> 2021-22 and 2022-23, (%)	90
30	Nitrogen uptake as influenced by nutrient levels during <i>Rabi</i> 2021-22, kg ha <sup>-1</sup>	93
31	Nitrogen uptake as influenced by nutrient levels during <i>Rabi</i> 2022-23, kg ha <sup>-1</sup>	94
32	Phosphorus uptake as influenced by nutrient levels during <i>Rabi</i> 2021-22, kg ha <sup>-1</sup>	95
33	Phosphorus uptake as influenced by nutrient levels during <i>Rabi</i> 2022-23, kg ha <sup>-1</sup>	96
34	Potassium uptake as influenced by nutrient levels during <i>Rabi</i> 2021-22, kg ha <sup>-1</sup>	97
35	Potassium uptake as influenced by nutrient levels during <i>Rabi</i> 2022-23, kg ha <sup>-1</sup>	98
36	Organic carbon, available N, P and K as influenced by nutrient levels during <i>Rabi</i> 2021-22	99
37	Organic carbon, available N, P and K as influenced by nutrient levels during <i>Rabi</i> 2022-23	100
38	Economics of cultivation, as influenced by nutrient levels during <i>Rabi</i> 2021-22	101
39	Economics of cultivation, as influenced by nutrient levels during <i>Rabi</i> 2022-23	102
40	Pooled analysis of economics of cultivation during <i>Rabi</i> 2021-22 and <i>Rabi</i> 2022-23	103
41	Effect of nutrient levels and varieties on plant height at 20 DAS and 40 DAS during <i>Rabi</i> 2023-24, cm	108
42	Effect of nutrient levels and varieties on plant height at 60 DAS and harvest during <i>Rabi</i> 2023-24, cm	109

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
43	Effect of nutrient levels and varieties on number of leaves per plant at 20 DAS and 40 DAS during <i>Rabi</i> 2023-24	110
44	Effect of nutrient levels and varieties on number of leaves per plant at 60 DAS during <i>Rabi</i> 2023-24	111
45	Effect of nutrient levels and varieties on number of branches per plant at 20 DAS and 40 DAS during <i>Rabi</i> 2023-24	112
46	Effect of nutrient levels and varieties on number of branches per plant at 60 DAS during <i>Rabi</i> 2023-24	113
47	Effect of nutrient levels and varieties on dry matter production at 20 DAS and 40 DAS during <i>Rabi</i> 2023-24, g per plant	114
48	Effect of nutrient levels and varieties on dry matter production at 60 DAS and harvest during <i>Rabi</i> 2023-24, g per plant	115
49	Effect of nutrient levels and varieties on leaf area index at 20 DAS and 40 DAS during <i>Rabi</i> 2023-24	120
50	Effect of nutrient levels and varieties on leaf area index at 60 DAS during <i>Rabi</i> 2023-24	121
51	Effect of nutrient levels and varieties on chlorophyll content at 20 DAS and 40 DAS during <i>Rabi</i> 2023-24, mg g <sup>-1</sup> fresh weight	122
52	Effect of nutrient levels and varieties on chlorophyll content at 60 DAS during <i>Rabi</i> 2023-24, mg g <sup>-1</sup> fresh weight	123
53	Effect of nutrient levels and varieties on crop growth rate during <i>Rabi</i> 2023-24, g m <sup>-2</sup> d <sup>-1</sup>	124
54	Effect of nutrient levels and varieties on crop growth rate at 60 DAS to harvest during <i>Rabi</i> 2023-24, g m <sup>-2</sup> d <sup>-1</sup>	125
55	Effect of nutrient levels and varieties on relative growth rate during <i>Rabi</i> 2023-24, g g <sup>-1</sup> d <sup>-1</sup>	126
56	Effect of nutrient levels and varieties on relative growth rate at 60 DAS to harvest during <i>Rabi</i> 2023-24, g g <sup>-1</sup> d <sup>-1</sup>	127
57	Effect of nutrient levels and varieties on days to 50 per cent flowering and number of capsules per plant during <i>Rabi</i> 2023-24	131
58	Effect of nutrient levels and varieties on number of seeds per capsule and hundred seed weight during <i>Rabi</i> 2023-24	132
59	Effect of nutrient levels and varieties on seed yield during <i>Rabi</i> 2023-24	133
60	Effect of nutrient levels and varieties on haulm yield during <i>Rabi</i> 2023-24	134
61	Effect of nutrient levels and varieties on harvest index during <i>Rabi</i> 2023-24	135

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
62	Effect of nutrient levels and varieties on oil content and crude protein content in seeds during <i>Rabi</i> 2023-24, %	138
63	Effect of nutrient levels and varieties on phosphorus and calcium content in seeds during <i>Rabi</i> 2023-24, %	139
64	Effect of nutrient levels and varieties on magnesium and iron content in seeds during <i>Rabi</i> 2023-24, %	140
65	Effect of nutrient levels and varieties on zinc content in the seeds during <i>Rabi</i> 2023-24, %	141
66	Effect of nutrient levels and varieties on nitrogen uptake by seed and haulm during <i>Rabi</i> 2023-24, kg ha <sup>-1</sup>	144
67	Effect of nutrient levels and varieties on total nitrogen uptake during <i>Rabi</i> 2023-24, kg ha <sup>-1</sup>	145
68	Effect of nutrient levels and varieties on phosphorus uptake by seed and haulm during <i>Rabi</i> 2023-24, kg ha <sup>-1</sup>	146
69	Effect of nutrient levels and varieties on total phosphorus uptake during <i>Rabi</i> 2023-24, kg ha <sup>-1</sup>	147
70	Effect of nutrient levels and varieties on potassium uptake by seed and haulm during <i>Rabi</i> 2023-24, kg ha <sup>-1</sup>	148
71	Effect of nutrient levels and varieties on total potassium uptake during <i>Rabi</i> 2023-24, kg ha <sup>-1</sup>	149
72	Effect of nutrient levels and varieties on organic carbon and available N during <i>Rabi</i> 2023-24	152
73	Effect of nutrient levels and varieties on available P and K during <i>Rabi</i> 2023-24	153
74	Effect of nutrient levels and varieties on gross return during <i>Rabi</i> 2023-24, ₹ ha <sup>-1</sup>	155
75	Effect of nutrient levels and varieties on net return during <i>Rabi</i> 2023-24, ₹ ha <sup>-1</sup>	156
76	Effect of nutrient levels and varieties on B:C ratio during <i>Rabi</i> 2023-24	157
77	Effect of leachates of sesame varieties on number of seeds/ tubers germinated and germination percentage of <i>Alternanthera sessilis</i> , <i>Setaria barbata</i> and <i>Cyperus rotundus</i>	160

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
78	Effect of leachates of sesame varieties on seedling shoot length and root length of <i>Alternanthera sessilis</i> , <i>Setaria barbata</i> and <i>Cyperus rotundus</i> , cm	160
79	Effect of leachates of sesame varieties on seedling fresh weight and dry weight of <i>Alternanthera sessilis</i> , <i>Setaria barbata</i> and <i>Cyperus rotundus</i> ,	161
80	Effect of leachates of sesame varieties on seedling vigour index I and II of <i>Alternanthera sessilis</i> , <i>Setaria barbata</i> and <i>Cyperus rotundus</i>	161
81	Effect of leachates of sesame varieties on number of seeds germinated and germination percentage of cowpea, okra and amaranthus	162
82	Effect of leachates of sesame varieties on seedling shoot length and root length of cowpea, okra and amaranthus, cm	162
83	Effect of leachates of sesame varieties on seedling fresh weight and dry weight of cowpea, okra and amaranthus, g	163
84	Effect of leachates of sesame varieties on seedling vigour index I and II of cowpea, okra and amaranthus	163

## LIST OF FIGURES

Figure No.	Title	Between pages
1	Weather data of experiment I (2021-22)	30-31
2	Weather data of experiment I (2022-23)	30-31
3	Weather data of experiment II (2023-24)	30-31
4a	Layout of experiment I during 2021-22	30-31
4b	Layout of experiment I during 2022-23	30-31
5	Seed cum fertilizer drill: front-right and left side diagram	34-35
6	Layout of experiment II during 2023-24	36-37
7	Effect of nutrient levels on DMP at harvest during 2021-22 and 2022-23	169-170
8	Effect of nutrient levels on LAI at 60 DAS during 2021-22 and 2022-23	171-172
9	Effect of nutrient levels on number of capsules per plant during 2021-22 and 2022-23	171-172
10	Effect of nutrient levels on number of seeds per capsule during 2021-22 and 2022-23	171-172
11	Effect of nutrient levels on seed yield ha <sup>-1</sup> during 2021-22 and 2022-23	171-172
12	Effect of nutrient levels on pooled seed yield ha <sup>-1</sup>	173-174
13	Response curve for N, during 2021-22	173-174
14	Response curve for P, during 2021-22	173-174
15	Response curve for K, during 2021-22	173-174
16	Response curve for N during 2022-23	173-174
17	Response curve for P during 2022-23	173-174
18	Response curve for K during 2022-23	173-174
19	Effect of nutrient levels on crude protein content during 2021-22 and 2022-23	175-176
20	Effect of nutrient levels on total N uptake during 2021-22 and 2022-23	175-176
21	Effect of nutrient levels on total P uptake during 2021-22 and 2022-23	177-178
22	Effect of nutrient levels on total K uptake during 2021-22 and 2022-23	177-178

<b>Figure No.</b>	<b>Title</b>	<b>Between pages</b>
23	Effect of nutrient levels and varieties on DMP at harvest during 2023-24	181-182
24	Interaction effect of nutrient levels and varieties on DMP at harvest during 2023-24	181-182
25	Effect of nutrient levels and varieties on LAI at 60 DAS during 2023-24	183-184
26	Interaction effect of nutrient levels and varieties on LAI at 60 DAS during 2023-24	183-184
27	Effect of nutrient levels and varieties on number of capsules per plant during 2023-24	187-188
28	Interaction effect of nutrient levels and varieties on number of capsules per plant during 2023-24	187-188
29	Effect of nutrient levels and varieties on seed yield ha <sup>-1</sup>	187-188
30	Interaction effect of nutrient levels and varieties on seed yield ha <sup>-1</sup>	187-188

## LIST OF PLATES

Plate No.	Title	Between pages
1	General view of experiment field during 2021-22	32-33
2	General view of experiment field during 2022-23	32-33
3	Field preparation and layout of experiment I	32-33
4	Seed cum fertilizer drill	34-35
5	Growth stages of the crop	34-35
6	General view of experiment field during 2023-24	36-37
7	Layout of experiment during 2023-24	36-37
8	Growth stages of crop during 2023-24	36-37
9	Best treatment during 2021-22	171-172
10	Best treatment during 2022-23	171-172
11	Capsules of different sesame varieties chosen for the study	185-186
12	Seeds of different sesame varieties chosen for the study	185-186
13	Best treatment during 2023-24	187-188
14	Inhibitory effect of leachate of variety GT 10 on <i>Alternanthera sessilis</i>	193-194
15	Inhibitory effect of leachate of variety GT 10 on <i>Setaria barbata</i>	193-194
16	Inhibitory effect of leachate of variety GT 10 on <i>Cyperus rotundus</i>	193-194
17	Inhibitory effect of leachate of variety GT 10 on cowpea	193-194
18	Inhibitory effect of leachate of variety GT 10 on okra	193-194

## LIST OF APPENDICES

<b>Sl. No.</b>	<b>Title</b>	<b>Appendix No.</b>
1	Weather parameters during of experiment I during 2021-22	I
2.	Weather parameters during of experiment I during 2022-23	II
3.	Weather parameters during of experiment II during 2023-24	III
4.	Cost of cultivation of experiment I	IV
5.	Cost of cultivation of experiment II	V
6.	Cost of inputs used	VI

## LIST OF ABBREVIATIONS

AEU	Agro ecological unit
ANOVA	Analysis of variance
AR	<i>Alternanthera sessilis</i>
ARS	Agricultural Research Station
BCR	Benefit cost ratio
Ca	Calcium
CCD	Central composite design
CD	Critical difference
CGR	Crop growth rate
cm	Centimetre
cm <sup>2</sup>	Square centimetre
CR	<i>Cyperus rotundus</i>
CRD	Completely randomized design
CRS	Coconut Research Station
DAS	Days after sowing
DMP	Dry matter production
dS m <sup>-1</sup>	Deci Seimens per metre
EC	Electrical conductivity
EC	Emulsion concentrate
<i>et al.</i>	Co-workers/ Co-authors
<i>fb</i>	Followed by
FIB	Farm Information Bureau
Fig.	Figure
Fe	Iron
FYM	Farmyard manure
g	Gram
GoI	Government of India
h	hours
ha	Hectare
ha <sup>-1</sup>	Per hectare
HI	Harvest index
IAA	Indole acetic acid

<i>i.e.</i>	That is
K	Potassium
K <sub>2</sub> O	Potassium oxide
KAU	Kerala Agricultural University
kg	Kilogram
kg ha <sup>-1</sup>	Kilogram per hectare
L	Litre
LAI	Leaf area index
m	Metre
MAP	Month after planting
Mg	Magnesium
mg g <sup>-1</sup>	Milligram per gram
mm	Millimetre
Mn	Manganese
MOP	Muriate of potash
MSL	Mean sea level
mL L <sup>-1</sup>	Milliliter per litre
N	Nitrogen
No.	Number
NS	Not significant
ORARS	Onattukara Regional Agricultural Research Station
P	Phosphorus
pH	Potenz Hydrogen
PoP	Package of Practices
P <sub>2</sub> O <sub>5</sub>	Phosphorus pentoxide
RBD	Randomized block design
RGR	Relative growth rate
RRS	Regional Research Station
₹ ha <sup>-1</sup>	Rupees per hectare
SEm	Standard error of means
SB	<i>Setaria barbata</i>
SOC	Soil organic carbon

SVI I	Seedling vigour index I
SVI II	Seedling vigour index II
t	Tonnes
t ha <sup>-1</sup>	Tonnes per hectare
<i>viz.</i>	Namely
w/v	Weight/Volume
Zn	Zinc

## LIST OF SYMBOLS

%	Percent
@	At the rate
°C	Degree Celsius
μ	Micro
₹	Rupees
<sup>0</sup> E	Degree East
<sup>0</sup> N	Degree North
±	Plus-minus sign
=	equal to
>	greater than
×	Multiplication

# **INTRODUCTION**

## 1. INTRODUCTION

Oilseeds are one of the most important field crops in terms of acreage, production and economic value, next to cereals and pulses. The virtue of oilseed crops is underscored by its role in global food security and economic stability. The ‘yellow revolution’ in the early 1990’s marked significant effort to boost the production of oilseeds. Sesame (*Sesamum indicum* L.), commonly known as gingelly, is one of the ancient and important oleaginous crop used by mankind. It is cultivated mainly for its highly priced oil and serves as a catch crop for small landholders in developing nations. The seeds of sesame are rich in vitamins A, B complex, E and minerals viz., phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn) and copper (Cu).

Sesame seeds contain the highest oil content (60%) compared to other oilseed crops such as soybean (20%), mustard (40%), sunflower (45%) and groundnut (50%) (Dossa *et al.*, 2018). The oil is a rich source of protein (24%), carbohydrate (13.5%), vitamins (A and E), minerals and dietary energy (6355 kcal kg<sup>-1</sup>) (Gharbi *et al.*, 2018). High levels of monounsaturated fatty acids like oleic acid (40-50%), enhance the quality of oil for human consumption. The natural antioxidants such as sesamin, sesamol and sesamolins makes sesame oil stable and free from rancidity. Sesame offers wide range of health benefits, as it bestows anti-oxidative, anti-carcinogenic, anti-inflammatory and anti-hypersensitive properties. In addition, the oil is used in pharmacology and in the manufacture of soaps, perfumes, paints and insecticides. Sesame meal left after oil processing is an excellent source of protein and is used as animal feed. The innumerable benefits of sesame have expanded its market and is expected to reach US \$17.77 billion by the end of 2025 (Lukurugu *et al.*, 2023).

India ranks first in the cultivation of sesame, accounting for more than 40 per cent of world’s area and 27 per cent of world’s production (FAOSTAT, 2022). Nevertheless, the productivity of sesame in India (0.41 t ha<sup>-1</sup>) was lower than the global average (0.53 t ha<sup>-1</sup>) (Indiastat, 2021). Cultivation of sesame, in marginal and sub marginal lands with inconsistent availability of water and input starved

conditions are the major reasons behind the lower productivity. Under well-managed conditions sesame could produce a seed yield of 1200-1500 kg ha<sup>-1</sup> and 800-1000 kg ha<sup>-1</sup> under irrigated and rain fed conditions, respectively (Ranganatha *et al.*, 2013). In Kerala, *Onattukara* sandy loam tract is the major sesame growing region where it is raised as the third crop in summer rice fallows. It is also cultivated in Thiruvananthapuram, Thrissur, Ernakulam and Wayanad districts to a limited extent.

Although crop production employs different inputs, nutrient management is of profound importance in sustaining crop growth and soil health. Proper management of nutrients like, nitrogen (N), phosphorus (P) and potassium (K) are essential in governing better crop growth, yield and environmental stewardship. Nitrogen has significant role in plant growth, since it is the primary component of amino acids, nucleic acids and chlorophyll. Phosphorus is a vital element required for various cellular functions like maintenance of membrane structures, synthesis of biomolecules and production of high energy molecules. Potassium is involved in enzyme activation, stomatal regulation and translocation of sugars. Efficient nutrient management strategies aim to optimize the fertilizer use, reduce production costs and devote to sustainable agriculture and climate change mitigation. Extensive research over decades, have led to development of nutrient recommendations for different crops. However, considering the inherent nutrient variability at different locations, blanket recommendations often fail to produce the potential yield. In addition, non-adoption of fertilizer responsive improved varieties suitable for specific agro-ecosystems, decreased the productivity, quality and resilience to pests and diseases.

Agro-ecological delineations are aimed at identifying and characterizing areas with similar agro-climatic conditions to optimize agricultural production. Ecological intensification is conceptualized to increase crop yields per unit land, time and other inputs used in cultivation. Kerala has been divided into 23 agro ecological units (AEUs) based on the homogeneity in climate, geography and land form, characterised by distinct responses to nutrients (Nair *et al.*, 2012). Evolving

agronomic packages particularly for AEUs, would essentially require standardizing nutrient dose for crops.

The agro ecological unit 8 of Kerala (Southern Laterites) covers 5 blocks viz., Athiyannur, Parassala, Nemom, Vellanad and Perumkadavila) in south-western part of Thiruvananthapuram district and is mainly occupied by coconut in the uplands. Coconut being a widely spaced crop does not fully utilize the available resources viz., land, water and nutrients. Hence, there is ample scope of enhancing the per capita availability of land by inclusion of intercrops in the interspaces of coconut. In the recent past, it was a common practice for farmers to grow sesame in the red loam soils of AEU 8 as an intercrop in coconut. Excellent performance of sesame in partially shaded conditions of Vellayani, was reported by Girijadevi (1983) and Santhosh (1988). However, farmers withdrew from the traditional practice of sesame cultivation due to lack of high yielding varieties and improved nutrient management practices suitable for this region. Adoption of fertilizer responsive, high yielding varieties (HYVs) and development of agro techniques particularly for this region are indispensable for reviving the cultivation of sesame.

Yield losses due to weeds and environmental pollution associated with the excessive use of synthetic herbicides, has highlighted the importance of sustainable weed management by integrating multiple weed control tactics, while minimizing reliance on herbicides. To address this issue, allelopathy; the biochemical interaction between plants through the release of secondary metabolites into the environment has gained popularity. Inclusion of allelopathic crops in intercropping, cover cropping, green manuring and developing bio-herbicides from the plant extracts of allelopathic crops are found effective to control weeds (Haider *et al.*, 2015). Allelochemicals helps in controlling the weeds by disrupting germination and seedling growth (Zhang *et al.*, 2020). Allelopathic effect of crops on weeds can also be effectively harnessed as an organic weed management tool.

Similarly crops with allelopathic effect may affect the germination and growth of other crops grown in rotation or intercropping. Identification of such

allelopathic interactions help to identify the inhibitory or stimulatory effect between different crops and aid in selection of suitable crops in multiple cropping.

In the light of the above facts, the present investigation entitled ‘Agro techniques for sesame (*Sesamum indicum* L.) under partial shade of coconut in Southern Laterites’ was undertaken with the following objectives.

- Standardization of nutrient levels for sesame under partial shade of coconut in Southern Laterites
- Assessment of response of promising sesame varieties to the identified optimum nutrient levels
- Assessment of the allelopathic effect of sesame on selected weeds and crops

# **MATERIALS AND METHODS**

### 3. MATERIALS AND METHODS

The study entitled “Agro-techniques for sesame (*Sesamum indicum* L.) under partial shade of coconut in Southern Laterites” was undertaken to standardize the nutrient levels for sesame under partial shade of coconut in Southern Laterites, assess the response of promising sesame varieties to the identified optimum nutrient levels and evaluate the allelopathic effect of sesame on selected weeds and crops. The materials used and the methods adopted for the study are presented in this chapter.

The research programme comprised of three different experiments.

Experiment I: Standardization of nutrient levels for sesame under partial shaded coconut gardens in Southern Laterites

Experiment II: Assessment of the response of promising sesame varieties to the identified optimum nutrient levels

Experiment III: Assessment of the allelopathic potential of sesame

Experiment III a. Assessment of the allelopathic effect of sesame on selected weeds

Experiment III b. Assessment of the allelopathic effect of sesame on selected crops

#### 3.1 GENERAL DETAILS

##### 3.1.1. Experimental Site

The project work was undertaken at Coconut Research Station (CRS), Balaramapuram, Thiruvananthapuram, Kerala located at 8° 22' 52" North latitude, 77° 1' 47" East longitude and at an altitude of 9 m above the mean sea level (MSL).

##### 3.1.2 Soil

The site of experiment I and II belongs to red sandy loam textural class with acidic reaction. The physical and chemical properties of the soil were analyzed as per the standard procedures and are detailed in Table 1.

##### 3.1.3 Season and Climate

The experiment on standardization of nutrient levels for sesame under partial shaded coconut gardens in Southern Laterites was conducted during *Rabi* 2021-22 and repeated for confirmation in *Rabi* 2022-23. The study on the

assessment of response of promising sesame varieties to the identified optimum nutrient levels was conducted during *Rabi* 2023-24.

The data on mean maximum and minimum temperatures, relative humidity and rainfall were collected from the Class B Agromet Observatory attached to CRS, Balaramapuram. The parameters are given in Appendix I, II and III as standard week averages and graphically presented in Fig.1, 2 and 3.

### **3.1.4 Cropping History of the Experimental Sites**

The crop was raised in the inter spaces of coconut palms (60 years old) planted at a spacing of 7.6 m x 7.6 m and having light transmission of 70 per cent. The experimental site of *Rabi* 2021-22 was previously cultivated with ragi and left fallow for one year prior to the cultivation of sesame. While, during *Rabi* 2022-23 and 2023-24, the experimental sites were left fallow prior to the experiment.

## **3.2 MATERIALS**

### **3.2.1 Planting Material**

Sesame variety Thilak, released from College of Agriculture, Vellayani, was used for experiment I. Seeds were procured from Onattukara Regional Agricultural Research Station (ORARS), Kayamkulam, Kerala. The experiment II was conducted with six short duration (85-90 days) sesame varieties *viz.*, Kayamkulam 1, Thilathara, Thilarani, Thilak, (procured from ORARS, Kayamkulam), GT 10 (procured from Agricultural Research Station (ARS), Amreli, Gujarat) and TMV 7 (from Regional Research Station (RRS), Vridhachalam, Tamil Nadu). The details of the varieties are presented in Table 2.

### **3.2.2 Manures and Fertilizers**

Well decomposed farm yard manure (FYM) with 0.58 per cent N, 0.34 per cent P<sub>2</sub>O<sub>5</sub> and 0.39 per cent K<sub>2</sub>O was used as organic manure. The fertilizers used as sources of N, P and K for the experiments were urea (46% N), rajphos (20% P<sub>2</sub>O<sub>5</sub>) and muriate of potash (60% K<sub>2</sub>O), respectively.

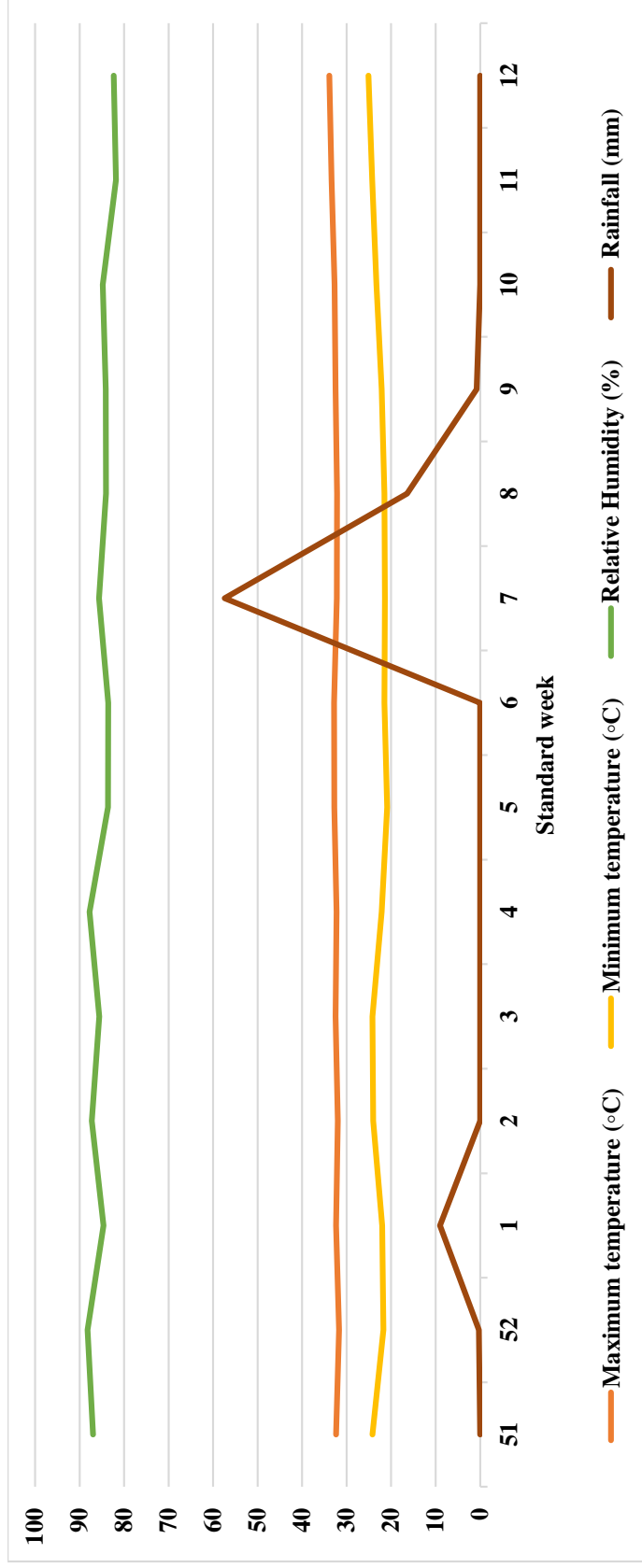


Fig.1. Weather data of experiment I (2021-22)

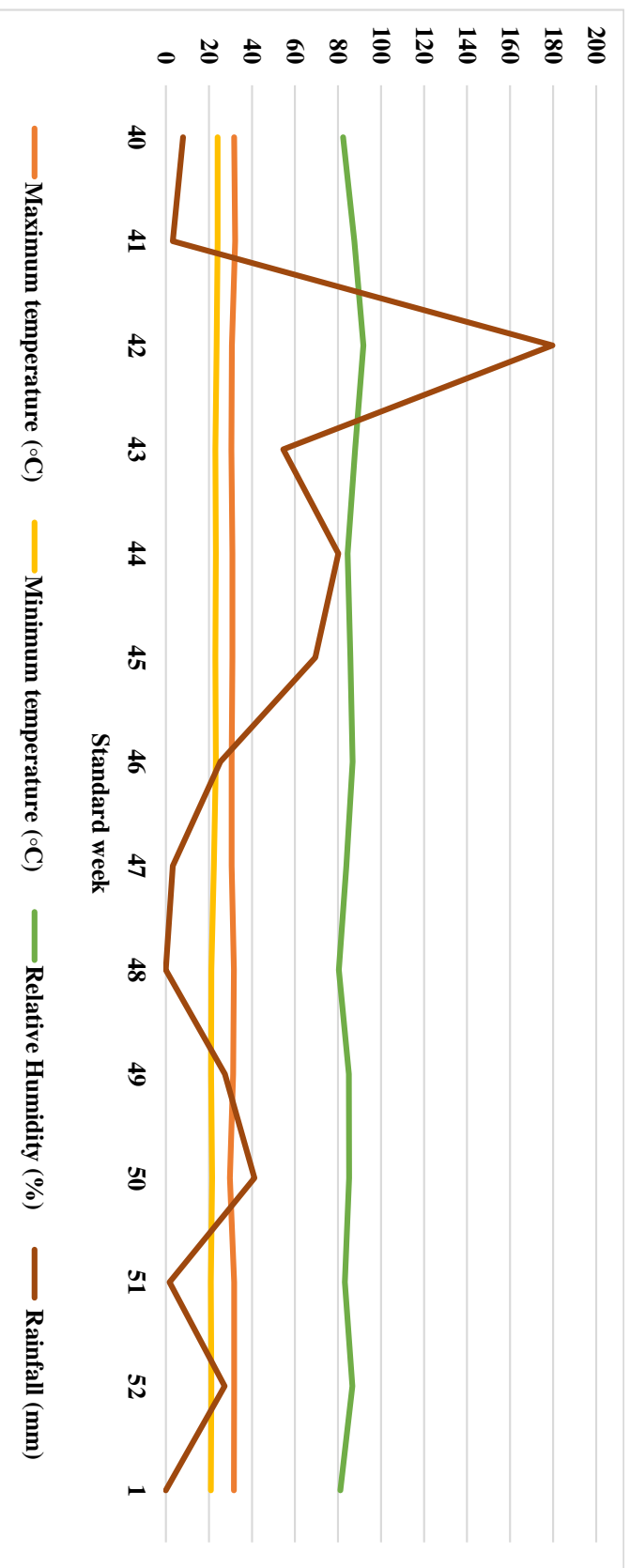


Fig.2. Weather data of experiment I (2022-23)

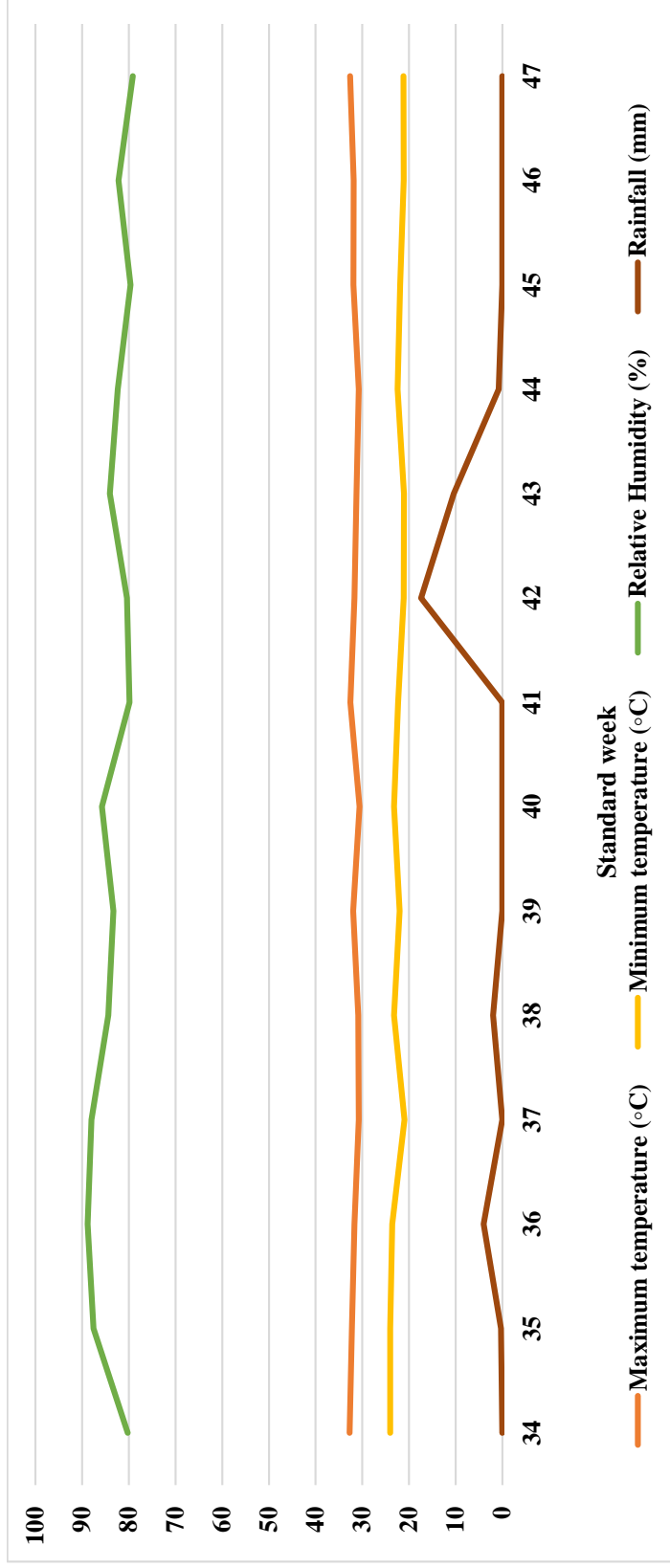


Fig.3. Weather data of experiment II (2023-24)

<b>R<sub>1</sub></b>	<b>R<sub>2</sub></b>	<b>R<sub>3</sub></b>
<b>T<sub>1</sub></b>	<b>T<sub>13</sub></b>	<b>T<sub>20</sub></b>
<b>T<sub>2</sub></b>	<b>T<sub>14</sub></b>	<b>T<sub>19</sub></b>
<b>T<sub>3</sub></b>	<b>T<sub>15</sub></b>	<b>T<sub>18</sub></b>
<b>T<sub>4</sub></b>	<b>T<sub>20</sub></b>	<b>T<sub>17</sub></b>
<b>T<sub>5</sub></b>	<b>T<sub>19</sub></b>	<b>T<sub>16</sub></b>
<b>T<sub>6</sub></b>	<b>T<sub>18</sub></b>	<b>T<sub>15</sub></b>
<b>T<sub>7</sub></b>	<b>T<sub>17</sub></b>	<b>T<sub>14</sub></b>
<b>T<sub>8</sub></b>	<b>T<sub>16</sub></b>	<b>T<sub>13</sub></b>
<b>T<sub>9</sub></b>	<b>T<sub>7</sub></b>	<b>T<sub>12</sub></b>
<b>T<sub>10</sub></b>	<b>T<sub>1</sub></b>	<b>T<sub>11</sub></b>
<b>T<sub>11</sub></b>	<b>T<sub>3</sub></b>	<b>T<sub>10</sub></b>
<b>T<sub>12</sub></b>	<b>T<sub>4</sub></b>	<b>T<sub>9</sub></b>
<b>T<sub>13</sub></b>	<b>T<sub>5</sub></b>	<b>T<sub>8</sub></b>
<b>T<sub>14</sub></b>	<b>T<sub>6</sub></b>	<b>T<sub>7</sub></b>
<b>T<sub>15</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>6</sub></b>
<b>T<sub>16</sub></b>	<b>T<sub>8</sub></b>	<b>T<sub>5</sub></b>
<b>T<sub>17</sub></b>	<b>T<sub>9</sub></b>	<b>T<sub>4</sub></b>
<b>T<sub>18</sub></b>	<b>T<sub>10</sub></b>	<b>T<sub>3</sub></b>
<b>T<sub>19</sub></b>	<b>T<sub>11</sub></b>	<b>T<sub>2</sub></b>
<b>T<sub>20</sub></b>	<b>T<sub>12</sub></b>	<b>T<sub>1</sub></b>

Fig. 4a. Layout of experiment I during 2021-22

<b>R<sub>1</sub></b>	<b>R<sub>2</sub></b>	<b>R<sub>3</sub></b>
<b>T<sub>1</sub></b>	<b>T<sub>13</sub></b>	<b>T<sub>20</sub></b>
<b>T<sub>2</sub></b>	<b>T<sub>14</sub></b>	<b>T<sub>19</sub></b>
<b>T<sub>3</sub></b>	<b>T<sub>15</sub></b>	<b>T<sub>18</sub></b>
<b>T<sub>4</sub></b>	<b>T<sub>20</sub></b>	<b>T<sub>17</sub></b>
<b>T<sub>5</sub></b>	<b>T<sub>19</sub></b>	<b>T<sub>16</sub></b>
<b>T<sub>6</sub></b>	<b>T<sub>18</sub></b>	<b>T<sub>15</sub></b>
<b>T<sub>7</sub></b>	<b>T<sub>17</sub></b>	<b>T<sub>14</sub></b>
<b>T<sub>8</sub></b>	<b>T<sub>16</sub></b>	<b>T<sub>13</sub></b>
<b>T<sub>9</sub></b>	<b>T<sub>7</sub></b>	<b>T<sub>12</sub></b>
<b>T<sub>10</sub></b>	<b>T<sub>1</sub></b>	<b>T<sub>11</sub></b>
<b>T<sub>11</sub></b>	<b>T<sub>3</sub></b>	<b>T<sub>10</sub></b>
<b>T<sub>12</sub></b>	<b>T<sub>4</sub></b>	<b>T<sub>9</sub></b>
<b>T<sub>13</sub></b>	<b>T<sub>5</sub></b>	<b>T<sub>8</sub></b>
<b>T<sub>14</sub></b>	<b>T<sub>6</sub></b>	<b>T<sub>7</sub></b>
<b>T<sub>15</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>6</sub></b>
<b>T<sub>16</sub></b>	<b>T<sub>8</sub></b>	<b>T<sub>5</sub></b>
<b>T<sub>17</sub></b>	<b>T<sub>9</sub></b>	<b>T<sub>4</sub></b>
<b>T<sub>18</sub></b>	<b>T<sub>10</sub></b>	<b>T<sub>3</sub></b>
<b>T<sub>19</sub></b>	<b>T<sub>11</sub></b>	<b>T<sub>2</sub></b>
<b>T<sub>20</sub></b>	<b>T<sub>12</sub></b>	<b>T<sub>1</sub></b>

Fig. 4b. Layout of experiment I during 2022-23

Table 1. Physico-chemical properties of soil of the experimental site

A. Mechanical composition

Sl. No.	Fractions	Content	Method
1	Sand (%)	66.45	Bouyoucos hydrometer method (Bouyoucos,1962)
2	Silt (%)	18.27	
3	Clay (%)	15.28	

B. Chemical properties

Sl. No.	Parameters	Content			Method
		Experiment I		Experiment II	
		<i>Rabi 2021-22</i>	<i>Rabi 2022-23</i>	<i>Rabi 2023-24</i>	
1	Soil reaction	4.70 (Acidic)	4.40 (Acidic)	4.50 (Acidic)	pH meter (1:2.5 soil water ratio) (Jackson, 1973)
2	EC, dSm <sup>-1</sup>	0.10 (Normal)	0.10 (Normal)	0.10 (Normal)	Conductivity meter (1:2.5 soil water ratio) (Jackson, 1973)
3	Organic carbon, %	0.81 (High)	0.77 (High)	0.79 (High)	Walkley and Black rapid titration method (Walkley and Black, 1934)
4	Available N, kg ha <sup>-1</sup>	160.52 (Low)	210.20 (Low)	186.47 (Low)	Alkaline permanganate method (Subbiah and Asija, 1956)
5	Available P, kg ha <sup>-1</sup>	28.15 (High)	30.60 (High)	27.31 (High)	Bray colorimetric method (Jackson, 1973)
6	Available K, kg ha <sup>-1</sup>	305.09 (High)	285.56 (High)	314.35 (High)	Ammonium acetate method (Jackson, 1973)

### 3.3 METHODS

#### 3.3.1 Experiment I- Standardization of Nutrient Levels for Sesame Under Partial Shaded Coconut Gardens in Southern Laterites

##### 3.3.1.1. *Experimental Design and Layout*

The details of the field experiment are given below. The lay out of the experiment is depicted in Fig. 4a and 4b.

Design	: Central Composite Design (CCD)
Factors	: 3
Experimental runs	: 20
Replications	: 3
Season	: <i>Rabi</i> 2021-22 and <i>Rabi</i> 2022-23
Variety	: Thilak
Spacing	: 30 cm x 15 cm
Plot size	: 4.2 m x 3.0 m

##### 3.3.1.2. *Treatment Details*

The NPK levels were fixed so as to determine the optimum fertilizer dose for sesame under partial shaded coconut gardens, using CCD. The following combinations were used in 20 runs and replicated thrice. The test array consisted of 6 central points (T<sub>15</sub> to T<sub>20</sub>).

T <sub>1</sub> :	31:20:16	kg NPK ha <sup>-1</sup>
T <sub>2</sub> :	64:20:16	kg NPK ha <sup>-1</sup>
T <sub>3</sub> :	31:50:16	kg NPK ha <sup>-1</sup>
T <sub>4</sub> :	64:50:16	kg NPK ha <sup>-1</sup>
T <sub>5</sub> :	31:20:34	kg NPK ha <sup>-1</sup>
T <sub>6</sub> :	64:20:34	kg NPK ha <sup>-1</sup>
T <sub>7</sub> :	31:50:34	kg NPK ha <sup>-1</sup>
T <sub>8</sub> :	64:50:34	kg NPK ha <sup>-1</sup>
T <sub>9</sub> :	20:35:25	kg NPK ha <sup>-1</sup>
T <sub>10</sub> :	75:35:25	kg NPK ha <sup>-1</sup>



Plate 1. General view of experiment field during 2021-22



Plate 2. General view of experiment field during 2022-23



Plate 3. Field preparation and layout of experiment I

T <sub>11</sub> :	48:10:25	kg NPK ha <sup>-1</sup>
T <sub>12</sub> :	48:60:25	kg NPK ha <sup>-1</sup>
T <sub>13</sub> :	48:35:10	kg NPK ha <sup>-1</sup>
T <sub>14</sub> :	48:35:40	kg NPK ha <sup>-1</sup>
T <sub>15</sub> :	48:35:25	kg NPK ha <sup>-1</sup>
T <sub>16</sub> :	48:35:25	kg NPK ha <sup>-1</sup>
T <sub>17</sub> :	48:35:25	kg NPK ha <sup>-1</sup>
T <sub>18</sub> :	48:35:25	kg NPK ha <sup>-1</sup>
T <sub>19</sub> :	48:35:25	kg NPK ha <sup>-1</sup>
T <sub>20</sub> :	48:35:25	kg NPK ha <sup>-1</sup>

### **3.3.1.3 Field Preparation**

Using garden tiller, the experimental site was ploughed to a fine tilth. The field was cleared of weeds and stubbles and levelled thoroughly. The experiment was laid out as per the layout. Gross plot size of the treatment plot was 4.2 m x 3.0 m. Bunds of 15 cm width were taken around all treatment plots. Lime was applied uniformly @ 250 kg ha<sup>-1</sup> during both the seasons.

### **3.3.1.4 Planting**

Seeds were sown on 16-12-21 during *Rabi* 2021-22 and 01-10-22 during *Rabi* 2022-23, using seed cum fertilizer drill. The seed rate adopted was 4 kg ha<sup>-1</sup> and spacing was 30 cm x 15 cm.

#### **3.3.1.4.1 Seed Cum Fertilizer Drill**

Seed cum fertilizer drill is a machinery used to plant seeds in rows and fertilize them simultaneously (Fig 6). Plant spacing and inter-row spacing can be adjusted according to crop requirements. The machine works by opening furrows, placing seeds and fertilizers in furrows and covering them with soil. This manually operated machinery takes an hour to plant crops at an inter-row spacing of one feet in ten cents (0.04 ha). It was developed by Kerala Agricultural University (patent certificate number, 127005 and design number, 359570-001, dated 28/02/2022 by

the patent office of Government of India). The technical specifications of the machine are depicted in Table 2.

#### ***3.3.1.5 Application of Manures and Fertilizers***

Dried and powdered FYM (5 t ha<sup>-1</sup>) was incorporated in the plots at the time of final ploughing. The fertilizers were given in two splits, basal and one month after planting (MAP), as per the treatments. Full dose of P and K and 75 per cent N was applied basally. Remaining N was given as foliar spray at 3 per cent concentration, 30 days after sowing (DAS).

#### ***3.3.1.6 Thinning and Weeding***

Thinning and gap filling were done on 15 DAS, retaining two seedlings per hill.

#### ***3.3.1.7 Weed Management***

Weeding was done manually, at 15 DAS and 30 DAS using wheel hoe weeder to check the weed population.

#### ***3.3.1.8 Irrigation***

The crop was raised as rainfed condition. Irrigation was given during the initial stages of crop growth and critical stages viz., flowering and capsule formation.

#### ***3.3.1.9 Plant Protection***

Mild incidence of mite attack and powdery mildew were noticed in the plants. Mite attack was managed with the foliar application of dimethoate @ 1.5 mL L<sup>-1</sup> and powdery mildew was controlled by spraying carbendazim @ 1g L<sup>-1</sup>.

#### ***3.3.1.10 Harvest***

The crop was harvested on 15/03/2022 during 2021-22 and on 04/01/2023 during 2022-23, when the capsules turned yellow and lower leaves started shedding. The plants were harvested by uprooting the whole plant after light irrigation. The net plot area of each treatment was harvested and bundled after the harvest of border

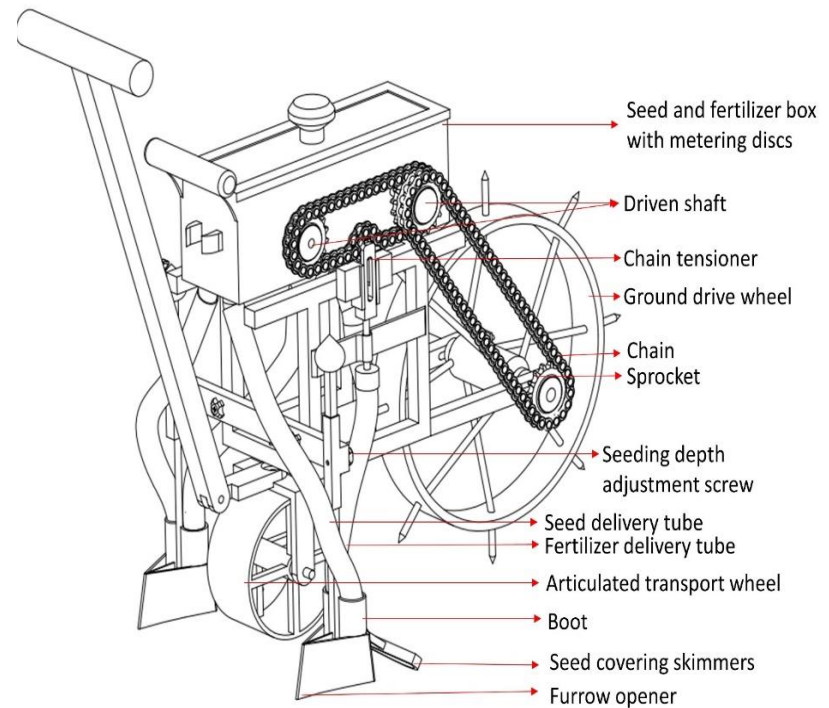
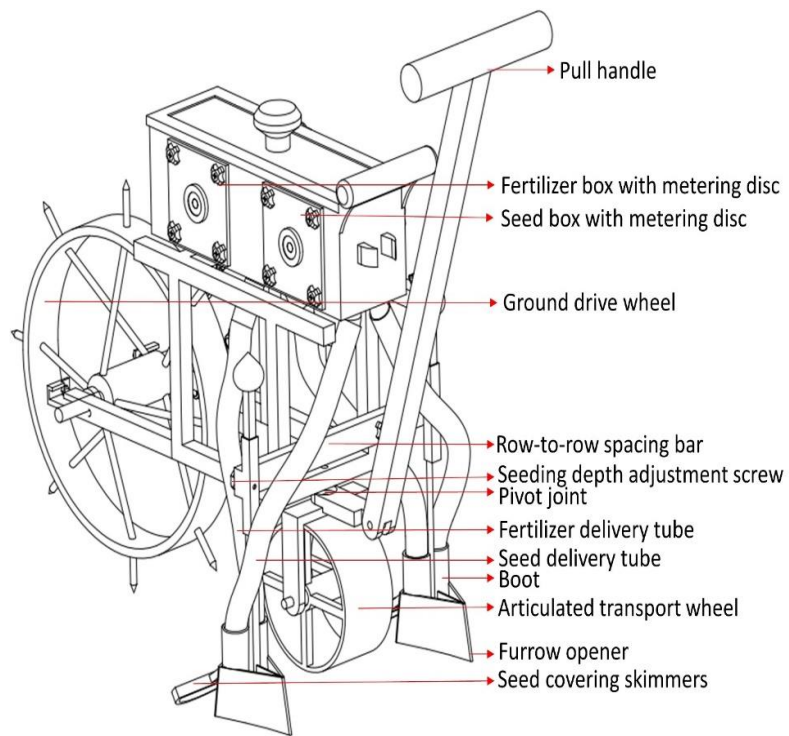


Fig. 5. Seed cum fertilizer drill: front-right and left side diagram



Plate 4. Seed cum fertilizer drill



Germination



20 DAS



Flowering



40 DAS



60 DAS



Harvest

Plate 5. Growth stages of the crop

Table 2. Technical specifications of seed cum fertilizer drill

<b>Parameters</b>	<b>Specifications</b>
Dimensions	Length-75 cm, breadth-20 cm, height-80 cm
Weight	18 kg
Furrow openers	Two
Furrow opener type	Shoe type
Depth of seeding and fertilization	0-5 cm
Row to row spacing	20-70 cm (adjustable)
Plant to plant spacing	10-50 cm (adjustable)
Capacity of seed and fertilizer box	0.25 kg
Power source	Manually operated
Seed and fertilizer metering mechanism	Disc and cell
Drive transmission	Chain and sprocket
Ground drive wheel	Lugged type
Area of operation	0.04 ha <sup>-1</sup>
Field capacity	85%
Crops suitable for seeding	Cereals, millets, pulses, oilseeds and vegetables

rows and sample plants. The bundles were kept in upright position for four days. After sun drying, the bundles were threshed to break open the capsules. The seeds were winnowed and sun dried. The weight of seeds and haulm from the net plot area were recorded on dry weight basis and expressed as seed yield and haulm yield per hectare.

### ***3.3.2 Experiment II-Assessment of the Response of Promising Sesame Varieties to the Identified Optimum Nutrient Levels***

#### ***3.3.2.1 Experiment Design and Layout***

The details of the field experiment are given below. The lay out is depicted in Fig. 7

Season	: Rabi 2023-24
Design	: Split plot
Replication	: 3
Spacing	: 30 cm x 15 cm
Plot size	: 4.2 m x 3 m

#### ***3.3.2.2 Treatment Details***

**Main plot : Nutrient dose-N (5 doses)**

n <sub>1</sub> :	] Identified optimum NPK from experiment I
n <sub>2</sub> :	
n <sub>3</sub> :	
n <sub>4</sub> :	

n<sub>5</sub> : KAU POP recommendation for sesame (30:15:30 kg ha<sup>-1</sup>)

**Sub plot : Varieties-V (6 varieties)**

v <sub>1</sub>	: Kayamkulam 1
v <sub>2</sub>	: Thilathara
v <sub>3</sub>	: Thilarani
v <sub>4</sub>	: Thilak
v <sub>5</sub>	: GT 10
v <sub>6</sub>	: TMV 7

Note: Treatments n<sub>1</sub> and n<sub>2</sub> were fixed based on the response surface curve using the seed yield (kg ha<sup>-1</sup>) of sesame during 2021-22.

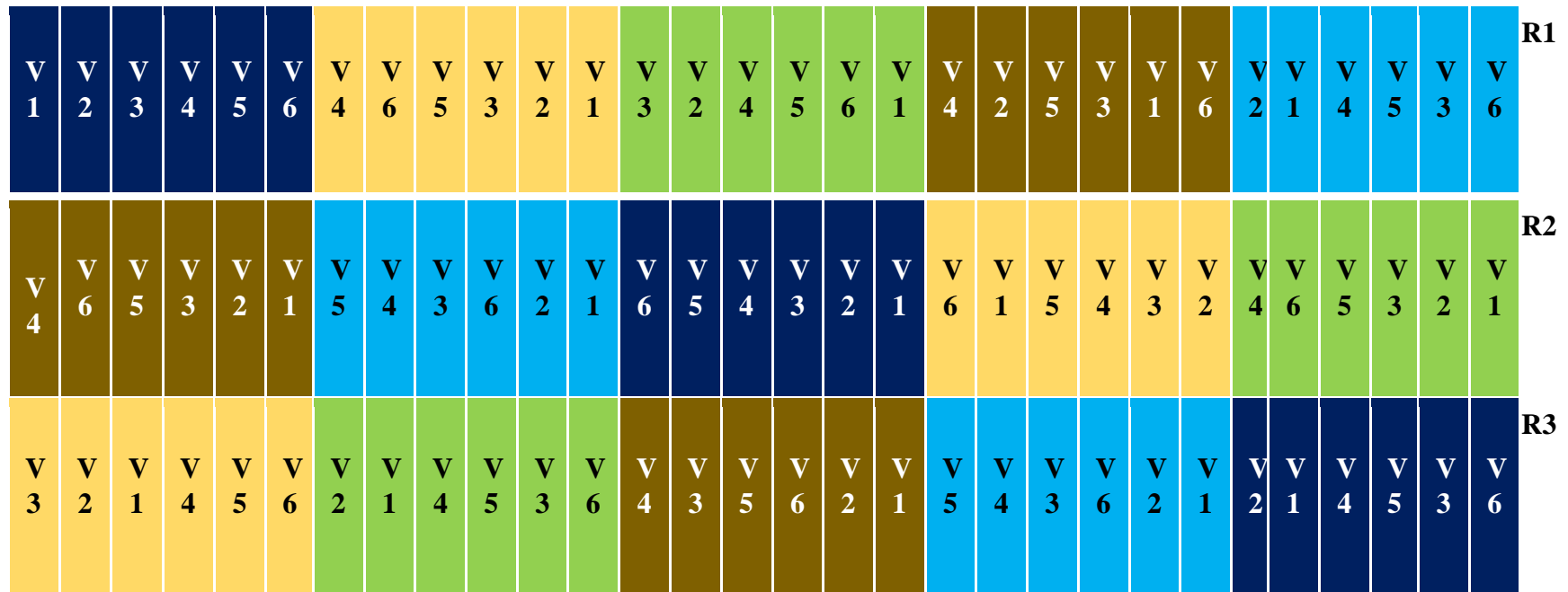


Fig.6. Layout of experiment II during 2023-24

- |   |  |
|---|--|
| <p><b>*Main plot (Nutrient levels, N)</b></p> <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: brown; margin-right: 5px;"></span> <math>n_1</math> - 35:26:7 kg NPK ha<sup>-1</sup></li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: darkblue; margin-right: 5px;"></span> <math>n_2</math> - 34:21:3 kg NPK ha<sup>-1</sup></li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: cyan; margin-right: 5px;"></span> <math>n_3</math> - 34:35:3 kg NPK ha<sup>-1</sup></li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: lightgreen; margin-right: 5px;"></span> <math>n_4</math> - 31:20:16 kg NPK ha<sup>-1</sup></li> <li><span style="display: inline-block; width: 15px; height: 15px; background-color: yellow; margin-right: 5px;"></span> <math>n_5</math> - 30:15:30 kg NPK ha<sup>-1</sup></li> </ul> | <p><b>*Sub plot (Varieties, V)</b></p> <ul style="list-style-type: none"> <li><math>v_1</math> - Kayamkulam 1</li> <li><math>v_2</math> - Thilathara</li> <li><math>v_3</math> - Thilarani</li> <li><math>v_4</math> - Thilak</li> <li><math>v_5</math> - GT 10</li> <li><math>v_6</math> - TMV 7</li> </ul> |
|---|--|



Plate 6. General view of experiment field during 2023-24



Plate 7. Layout of experiment II during 2023-24



20 DAS



40 DAS



60 DAS



Harvest

Plate 8. Growth stages of crop during 2023-24

Treatment n<sub>3</sub> was fixed based on the response surface curve using the seed yield (kg ha<sup>-1</sup>) of sesame during 2022-23.

Treatment n<sub>4</sub> was fixed based on the pooled analysis of seed yield (kg ha<sup>-1</sup>) during 2021-22 and 2022-23 using randomised block design (RBD).

#### ***3.3.2.3 Field Preparation***

The field was tilled to a fine tilth using garden tiller. The experiment was laid out as per the layout. Gross plot size of the plot was 4.2 m x 3.0 m. Lime was applied uniformly @ 250 kg ha<sup>-1</sup>.

#### ***3.3.2.4 Planting***

Seeds were sown manually using seed cum fertilizer drill, on 21-08-23 during 2023-24. The seed rate adopted was 4 kg ha<sup>-1</sup> and the spacing was 30 cm x 15 cm.

#### ***3.3.2.5 Application of Manures and Fertilizers***

Application of manures and fertilizers was done as described in ***3.3.1.5***.

#### ***3.3.2.6 Thinning and Weeding***

Thinning and gap filling were done as described in ***3.3.1.6***.

#### ***3.3.2.7 Weed Management***

Weeding was done as described in ***3.3.1.7***.

#### ***3.3.2.8 Irrigation***

Irrigation was done as described in ***3.3.1.8***.

#### ***3.3.2.9 Plant Protection***

Mild incidence of mite attack was observed and it was managed with the foliar application of dimethoate @ 1.5 mL L<sup>-1</sup>.

#### ***3.3.2.10 Harvest***

Harvesting of sesame was done on 21-11-23 as described under ***3.3.1.10***.

Table 3. Characteristics of sesame varieties chosen for the study

Varieties	Year of release	Seed yield (kg ha <sup>-1</sup> )	Oil content (%)	Days to maturity	Salient features
Kayamkulam 1	2006	600-650	48-50	80-85	Brownish black seeds, moderately branching, narrow oblong capsules, tolerant to drought
Thilathara	2006	600-650	48-52	84-88	Blackish brown seeds, moderately branching, resistant to powdery mildew
Thilarani	2006	650-750	46-50	82-86	Dark brown seeds, compact capsules, resistant to powdery mildew
Thilak	2006	600-650	48-50	85-90	Blackish brown seeds, highly branching, suitable for both rice fallow and <i>Rabi</i> upland, tolerant to moisture stress
TMV 7	2009	800-900	48-50	80-85	Brown seeds, high protein content (24.5 %), suitable for value addition, tolerant to root rot
GT 10	2002	750-800	48-52	88-92	Black seeds, profusely branching, pinkish white flower colour, resistant to powdery mildew

(Ranganatha *et al.*, 2013)

### **3.3.3. Experiment III-Assessment of the Allelopathic Potential of Sesame**

#### **3.3.3.1 Assessment of the Allelopathic Effect of Sesame on Selected Weeds**

Weeds selected : 3 (*Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*)

Method : Petri plate assay

Design : CRD

Replication : 4

Treatments : 7 (whole plant leachates of six sesame varieties and pure water as control)

##### **3.3.3.1.1 Treatment Details**

T<sub>1</sub> : Whole plant leachate of Kayamkulam 1

T<sub>2</sub> : Whole plant leachate of Thilathara

T<sub>3</sub> : Whole plant leachate of Thilarani

T<sub>4</sub> : Whole plant leachate of Thilak

T<sub>5</sub> : Whole plant leachate of GT 10

T<sub>6</sub> : Whole plant leachate of TMV 7

T<sub>7</sub> : Pure water (control)

##### **3.3.3.1.2 Preparation of Plant Leachate**

Fresh plant samples at active growth stage were collected from the field and washed thoroughly to remove dirt and soil. Plant parts were chopped into small pieces of 2 cm length using a plant cutter. The cut pieces (100 g) were soaked in 500 mL distilled water for 72 h to prepare leachates of 1:5 (w/v) concentration. The leachates were filtered using Whatman No.1 filter paper (Tomar *et al.*, 2015).

##### **3.3.3.1.3 Germination Bioassay**

Seeds of *Alternanthera sessilis*, *Setaria barbata* and tubers of *Cyperus rotundus* were used as the test crops for bioassay. Twenty seeds/rhizomes of each test crop were placed in the petri dish of 9 cm diameter, lined with filter paper. The filter paper was moistened on alternate days with 5 mL of leachate prepared from sesame varieties. Petri dish moistened using distilled water was taken as control.

The seeds of *Alternanthera sessilis* and *Setaria barbata* were kept for germination, for a period of 7 days. While the tubers of *Cyperus rotundus* were kept for 14 days. Seeds with emerged radicle (2mm) were considered as germinated. The

germinated seeds were counted at 24 h intervals. The experiment was repeated twice for confirmation.

### **3.3.3.2 Assessment of the Allelopathic Effect of Sesame on Selected Crops**

Crops selected : 3 (cowpea, okra and amaranthus)  
Method : Petri plate assay  
Design : CRD  
Replication : 4  
Treatments : 7 (whole plant leachates of six varieties of sesame and pure water as control)

#### **3.3.3.2.1 Treatment Details**

T<sub>1</sub> : Whole plant leachate of Kayamkulam 1  
T<sub>2</sub> : Whole plant leachate of Thilathara  
T<sub>3</sub> : Whole plant leachate of Thilarani  
T<sub>4</sub> : Whole plant leachate of Thilak  
T<sub>5</sub> : Whole plant leachate of GT 10  
T<sub>6</sub> : Whole plant leachate of TMV 7  
T<sub>7</sub> : Pure water (control)

#### **3.3.3.2.1 Preparation of Plant Leachate**

Plant leachates were prepared as described in 3.3.3.1.2.

#### **3.3.3.2.2 Germination Bioassay**

Cowpea (variety Vellayani Geethika), okra (variety Salkeerthi) and amaranthus (variety Arun) were used as the test crops for bioassay. Ten seeds of each test crop were placed in the petri dish of 9 cm diameter, lined with filter paper. The filter paper was moistened on alternate days with 5 mL of leachate prepared from sesame varieties. Petri dish moistened with distilled water was taken as control.

The seeds of okra were kept for germination, for a period of 21 days. While the seeds of cowpea and amaranthus were kept for 8 days each (Agarwal, 1994). Seeds with emerged radicle (2mm) were considered as germinated. The germinated seeds were counted at 24 h intervals. The experiment was repeated twice for confirmation.

## 3.4. OBSERVATIONS

### **3.4.1 Standardization of Nutrient Levels for Sesame under Partial Shaded Coconut Gardens in Southern Laterites and Assessment of the Response of Promising Sesame Varieties to Identified Optimum Nutrient Levels**

#### ***3.4.1.1 Biometric Observations***

Five plants were selected randomly from the net plot area in each plot and tagged as observational plants for recording biometric observations.

##### ***3.4.1.1.1 Height of the Plant***

Height of the observational plant was measured from the base to the growing tip and the average was expressed in cm at 20 DAS, 40 DAS, 60 DAS and harvest.

##### ***3.4.1.1.2 Number of Leaves per Plant***

The total number of leaves in each observational plant were recorded by counting the number of fully opened leaves from the base to the tip at 20 DAS, 40 DAS and 60 DAS.

##### ***3.4.1.1.3 Number of Branches per Plant***

The number of branches present in each observational plant were counted and the average was computed at 20 DAS, 40 DAS and 60 DAS.

##### ***3.4.1.1.4 Dry Matter Production***

Three plants were uprooted from each treatment plot outside the net plot at 20 DAS, 40 DAS, 60 DAS and harvest. The plants were oven dried at  $65 \pm 5^\circ\text{C}$  to constant dry weight and expressed as g per plant.

#### ***3.4.1.2 Physiological Parameters***

##### ***3.4.1.2.1 Total Chlorophyll Content***

Total chlorophyll content of leaves at 20 DAS, 40 DAS and 60 DAS was estimated by the method developed by Arnon (1949) and expressed in  $\text{mg g}^{-1}$  of fresh weight of the leaf.

$$\text{Total chlorophyll} = [8.02 A_{663} + 20.20 A_{645}] \times \frac{V}{1000 \times W}$$

where,

A : Absorbance at specific wavelengths (663 nm and 645nm)

V : Final volume of chlorophyll extract

W : Fresh weight of tissue extracted

#### 3.4.1.2.2 Leaf Area Index

Leaf area was computed by multiplying the length and maximum breadth of all leaves in the sample plant. The mean leaf area of the plant was calculated and multiplied by a constant 0.46 (Musa *et al.*, 2020).

The LAI at 20 DAS, 40 DAS and 60 DAS were calculated using the following formula (Watson, 1947).

$$\text{LAI} = \frac{\text{Leaf area of plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}}$$

#### 3.4.1.2.3 Crop Growth Rate (CGR)

The CGR at 20 DAS-40 DAS, 40 DAS-60 DAS and 60 DAS-harvest were calculated by the formula given by Watson (1952) and expressed as g m<sup>-2</sup> d<sup>-1</sup>.

$$\text{CGR} = \frac{(w_2 - w_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

where,

w<sub>1</sub> : Dry weight of plant (g) at time interval t<sub>1</sub>

w<sub>2</sub> : Dry weight of plant (g) at time interval t<sub>2</sub>

A : Unit land area (m<sup>2</sup>)

#### 3.4.1.2.4 Relative Growth Rate (RGR)

The RGR at 20 DAS-40 DAS, 40 DAS-60 DAS and 60 DAS-harvest were computed by the formula suggested by Evans (1972) and expressed as g g<sup>-1</sup>d<sup>-1</sup>.

$$\text{RGR} = \frac{(\log_e w_2 - \log_e w_1)}{(t_2 - t_1)}$$

where,  $w_2$  and  $w_1$  represent total dry matter per plant at time intervals  $t_2$  and  $t_1$ , respectively.

### ***3.4.1.3 Yield Attributes and Yield***

The observational plants were separately harvested for recording the following observations and the mean values were worked out.

#### ***3.4.1.3.1 Days to 50 Per cent Flowering***

The total number of days from the day of sowing to flowering by 50 per cent of the plants in each treatment plot was recorded as days to 50 per cent flowering

#### ***3.4.1.3.2 Number of Capsules per Plant***

The number of capsules in each observational plant was enumerated at harvest and the mean was worked out.

#### ***3.4.1.3.3 Number of Seeds per Capsule***

Ten capsules were randomly selected from the observational plants in each treatment plot and number of seeds in each capsule was counted. The average was calculated to obtain the number of seeds per capsule.

#### ***3.4.1.3.4 Hundred Seed Weight***

After threshing, 100 seeds from each treatment plot were oven dried, weighed and expressed in g.

#### ***3.4.1.3.5 Seed Yield per Plant***

The observational plants were harvested, sun dried, threshed and winnowed separately to obtain the seed yield per plant. Winnowed seeds were sun dried, weighed and expressed as g per plant.

#### **3.4.1.3.6 Seed Yield ha<sup>-1</sup>**

The plants in the net plot area were harvested, bundled and stacked in upright position for four days. The plants harvested from the net plot in each treatment plot were sun dried, threshed and winnowed to separate the seeds. Winnowed seeds were sun dried, weighed and expressed in kg ha<sup>-1</sup>.

#### **3.4.1.3.7 Haulm Yield per Plant**

To record the haulm yield per plant, the stover yield from the observational plants were dried under sun after threshing and expressed in g.

#### **3.4.1.3.8 Haulm Yield ha<sup>-1</sup>**

The stover yield from the net plot area was sun dried after threshing to record the haulm yield in kg ha<sup>-1</sup>.

#### **3.4.1.3.9 Harvest Index (HI)**

Harvest index was computed using the formula suggested by Donald and Hamblin (1976).

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

#### **3.4.1.4 Quality Parameters**

The seeds were analyzed for the oil percentage, crude protein, P, Ca, Mg, Fe and Zn content.

##### **3.4.1.4.1 Oil Percentage**

Oil percentage in the sesame seeds were estimated by Soxhlet extraction method (El-Tinay *et al.*, 1976).

##### **3.4.1.4.2 Crude Protein Content**

Crude protein content of the seed was calculated by multiplying the N content in seeds with the factor 6.25 and expressed in percentage (Simpson *et al.*, 1965).

#### **3.4.1.4.3 P, Ca, Mg, Fe and Zn Content of Seeds**

Standard methods were adopted for the analysis of P, Ca, Mg, Fe and Zn content of sesame seeds and are presented in Table 4.

#### **3.4.1.5 Chemical Analysis**

##### **3.4.1.5.1 Plant Analysis**

The seeds and haulm were analyzed separately for N, P and K content and the total was calculated. Samples were dried in oven at  $65 \pm 5^\circ\text{C}$  and powdered to pass through 0.5 mm mesh. For estimation of N, single acid digestion was followed while for P and K di acid digestion was followed. The standard procedures adopted for the analysis of N, P and K in the samples are presented in Table 5. The uptake of nutrients was calculated by multiplying the respective dry matter with the nutrient content and expressed in  $\text{kg ha}^{-1}$ .

##### **3.4.1.5.2 Soil Analysis**

Soil samples were analysed for organic C, available N, P and K before and after the experiments by adopting the standard procedures as described in Table 1.

#### **3.4.1.6 Economic Analysis**

The cost of cultivation and gross income were calculated based on existing market prices of various inputs, outputs and labour wages. The total cost of cultivation of experiment I, II and inputs used are given in Appendices IV, V and VI, respectively.

The economics of cultivation was worked out based on gross return, net return and benefit-cost ratio (BCR), which were computed as follows.

##### **3.4.1.6.1 Gross Return**

$$\text{Gross return } (\text{₹ ha}^{-1}) = \text{Seed yield} \times \text{Market price}$$

##### **3.4.1.6.2 Net Return**

$$\text{Net return } (\text{₹ ha}^{-1}) = \text{Gross return} - \text{Cost of cultivation}$$

Table 4. Standard methods adopted for the analysis of elements

Particulars	Method	Reference
P	Spectrophotometry method	Jackson (1973)
Ca	Nitric- Perchloric acid (9:4) digestion and atomic absorption spectrometry	Jackson (1958)
Mg		
Fe		
Zn		

Table 5. Methods for plant analysis

Particulars	Method	Reference
N	Micro-Kjeldahl digestion and distillation method	Jackson (1973)
P	Nitric-perchloric acid digestion (9:4) and spectrophotometry using vanadomolybdo phosphoric yellow colour method	
K	Nitric-perchloric acid digestion (9:4) and flame photometry	

#### **3.4.1.6.3 Benefit-cost ratio (BCR)**

$$\text{BCR} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

### **3.4.2 Experiment III-Assessment of the Allelopathic Potential of Sesame**

#### **3.4.2.1 Assessment of the Allelopathic Effect of Sesame on Selected Weeds**

##### **3.4.2.1.1 Number of Seeds/Tubers Germinated**

Number of seeds germinated were counted on each day up to eight DAS for *Alternanthera sessilis* and *Setaria barbata*. The number of tubers germinated were recorded up to 14 DAS for *Cyperus rotundus*.

##### **3.4.2.1.2 Seedling Root Length**

On the day of final germination count, root length of all the germinated seedlings were measured. The averages were worked out and expressed in cm.

##### **3.4.2.1.3 Seedling Shoot Length**

On the day of final germination count, shoot length of all the germinated seedlings were measured. The averages were worked out and expressed in cm.

##### **3.4.2.1.4 Seedling Fresh Weight**

Fresh weight of five randomly selected seedlings were recorded. The average was worked out and expressed in g.

##### **3.4.2.1.5 Seedling Dry Weight**

The samples were oven dried in hot air at  $65 \pm 5$  °C to a constant weight and the dry weight was expressed in g.

##### **3.4.2.1.6 Germination Percentage**

Germination percentage was calculated by the formula put forward by Agarwal (1994).

$$\text{Germination percentage} = \frac{\text{Total number of seeds/tubers germinated}}{\text{Total number of seeds/tubers sown}} \times 100$$

##### **3.4.2.1.7 Seedling Vigour Index I**

Seedling vigour index I (SVI I) of the seeds/tubers were worked out using the formula put forth by Abdul- Baki and Anderson (1973).

$$\text{SVI I} = \text{Seedling length (cm)} \times \text{germination percentage}$$

#### **3.4.2.1.8 Seedling Vigour Index II**

Seedling vigour index II (SVI II) of the seeds/tubers were worked out using the formula given by Abdul- Baki and Anderson (1973).

SVI II= Seedling dry weight (g) × germination percentage

#### **3.4.2.2 Assessment of the Allelopathic Effect of Sesame on Selected Crops**

##### **3.4.2.2.1 Number of Seeds Germinated**

Number of seeds germinated were counted on each day up to 7 DAS for amaranthus and cowpea and 21 DAS for okra.

##### **3.4.2.2.2 Seedling Root Length**

On the day of final germination count, root length of all the germinated seedlings were measured. The averages were worked out and expressed in cm.

##### **3.4.2.2.3 Seedling Shoot Length**

On the day of final germination count, shoot length of all the germinated seedlings were measured. The averages were worked out and expressed in cm.

##### **3.4.2.2.4 Seedling Fresh Weight**

Weight of five randomly selected seedlings were recorded. The average was worked out and expressed in g.

##### **3.4.2.2.5 Seedling Dry Weight**

The samples were oven dried at  $65 \pm 5$  °C to a constant weight and the dry weight was expressed in g.

##### **3.4.2.2.6 Germination Percentage**

Germination percentage was calculated by the formula as described in

#### **3.4.2.1.6**

##### **3.4.2.2.7 Seedling Vigour Index I**

Seedling Vigour Index I (SVI I) was worked out as described in 3.4.2.1.7.

##### **3.4.2.2.8 Seedling Vigour Index II**

Seedling Vigour Index II (SVI II) was worked as described in 3.4.2.1.8.

### **3.5 STATISTICAL ANALYSIS**

The data on seed yield ha<sup>-1</sup> of experiment I (*Rabi* 2021-22 and *Rabi* 2022-23) was analyzed statistically using CCD by plotting response surface curves to

determine the optimum NPK level for sesame in Southern Laterites. The NPK levels for experiment II were selected based on the estimated yield obtained from the response surface methodology (RSM).

All the remaining observations of experiment I were statistically analysed using randomized block design (RBD) with fifteen treatments (T<sub>1</sub>-T<sub>14</sub>, same as that of CCD, T<sub>15</sub>: average of treatments T<sub>15</sub>-T<sub>20</sub> in CCD), replicated thrice. The parameters were analysed using analysis of variance technique (ANOVA) suggested by Panse and Sukhatme (1985) for randomized block design (RBD) and the significance was tested by F test (Cochran and Cox, 1965). Wherever, F test was significant, the critical difference (CD) was calculated at five per cent probability level, for comparison of the treatments. The seed yield ha<sup>-1</sup> was also statistically analysed using RBD.

The data on various parameters of Experiment II and Experiment III were statistically analyzed using ANOVA for split plot design and CRD respectively. The significance was tested by F test and the CD was calculated at five per cent probability level, wherever F test was significant. The statistical analysis was done using the software, grapes Agri 1 (Gopinath *et al.*, 2021).

## **RESULTS**

## 4. RESULTS

The experiment entitled “Agro-techniques for sesame (*Sesamum indicum* L.) under partial shade of coconut in Southern Laterites” was conducted at Coconut Research Station, Balaramapuram with the objectives to standardize the nutrient levels for sesame under partial shade of coconut gardens in Southern Laterites, assess the response of promising sesame varieties to the identified optimum nutrient levels and evaluate the allelopathic effect of sesame on selected weeds and crops. The data collected were statistically analysed and the results of the study are presented in detail in this chapter.

### 4.1 EXPERIMENT I: STANDARDIZATION OF NUTRIENT LEVELS FOR SESAME UNDER PARTIAL SHADED COCONUT GARDENS IN SOUTHERN LATERITES

#### 4.1.1 Growth Characters

The growth characters of sesame *viz.*, plant height, number of leaves per plant, number of branches per plant and DMP were collected at timely intervals.

##### 4.1.1.1 Plant Height

The data on the effect of nutrient levels on plant height of sesame are presented in Tables 6a and 6b.

An increase in plant height was observed from 20 DAS to harvest. At 20 DAS, during 2021-22 and 2022-23, T<sub>1</sub> recorded taller plants (30.3 cm and 31.5 cm, respectively) and was on par with T<sub>2</sub> (28.1 cm and 30.7 cm, respectively). The shortest plants were observed in T<sub>13</sub>, during both years (17.3 cm and 20.0 cm respectively).

At 40 DAS, T<sub>1</sub> resulted in significantly taller plants (86.3 cm) during 2021-22, however, during 2022-23, T<sub>1</sub> (91.6 cm) was on par with T<sub>2</sub> (88.7 cm). The shortest plants were observed in T<sub>13</sub> during both years (49.4 cm and 59.1 cm, respectively).

Similarly, T<sub>1</sub> resulted in taller plants at 60 DAS (127.0 cm and 140.7 cm, respectively) and was on par with T<sub>2</sub> (119.9 cm and 136.8 cm, respectively) during both years. The shortest plants were observed in T<sub>13</sub> during both years (86.3 cm and 99.7 cm, respectively).

At harvest, during 2021-22, T<sub>1</sub> recorded taller plants (150.8 cm) and was on par with T<sub>2</sub> (142.1 cm). While, during 2022-23, T<sub>1</sub> (163.5 cm) was on par with T<sub>2</sub> (158.6 cm) and T<sub>4</sub> (156.7 cm). The shortest plants were noted in T<sub>13</sub> during both years (106.2 cm and 134.5 cm, respectively).

#### ***4.1.1.2 Number of Leaves per Plant***

Tables 7a and 7b depict that number of leaves per plant were markedly influenced by nutrient levels during both years. It was observed that number of leaves per plant decreased towards harvest.

During 2021-22, number of leaves per plant was greater in T<sub>1</sub> (8.3) and was on par with T<sub>7</sub> (8.0) and T<sub>2</sub> (7.7), at 20 DAS. While during 2022-23, T<sub>1</sub> resulted in greater number of leaves per plant (10.3) and was on par with T<sub>2</sub> (8.7). At 40 DAS during 2021-22, the greatest number of leaves per plant were noted in T<sub>1</sub> (35.3). However, during 2022-23, greater number of leaves per plant were observed in T<sub>1</sub> (37.7) and was on par with T<sub>2</sub> (36.0).

At 60 DAS also, T<sub>1</sub> recorded the greatest number of leaves per plant during both years (74.3 and 83.3, respectively). At harvest, number of leaves per plant were significantly influenced by nutrient levels only during 2021-22. Among the treatments T<sub>1</sub> produced the greatest number of leaves per plant (43.0).

During both years, number of leaves per plant were found to be the lowest in T<sub>13</sub> at all stages of observation.

#### ***4.1.1.3 Number of Branches per Plant***

Effect of nutrient levels on number of branches per plant at different growth stages are presented in Tables 8a and 8b.

At 20 DAS, during both years, nutrient levels did not have any significant effect on number of branches per plant. However, at 40 DAS during 2021-22, T<sub>1</sub> produced more number of branches per plant (5.7) and was on par with T<sub>2</sub> (4.7). Whereas, during 2022-23, greater number of branches per plant were observed in T<sub>1</sub> (6.0) which was on par with T<sub>2</sub> (5.0) and T<sub>4</sub> (4.7).

At 60 DAS, greater number of branches per plant was observed in T<sub>1</sub> during 2021-22 and 2022-23 (8.3 and 9.3, respectively) and was on par with T<sub>2</sub> (8.0 and 8.7, respectively). Similarly at harvest also, T<sub>1</sub> produced greater number of branches per plant (9.0) and was on par with T<sub>2</sub> during 2021-22 (8.7). While, during 2022-23, greater number of branches per plant was observed in T<sub>2</sub> (10.7) and was on par with T<sub>1</sub> (10.0). The lowest number of branches per plant were observed in T<sub>13</sub> at all stages of observation, during both years.

#### ***4.1.1.4 Dry Matter Production (DMP)***

Effect of nutrient levels on DMP at different growth stages of sesame are given in Table 9a and 9b.

Dry matter production was significantly higher in T<sub>1</sub> at 20 DAS, 40 DAS, 60 DAS and harvest during 2021-22 (1.12, 9.92, 15.70 and 18.72 g per plant, respectively) and 2022-23 (1.27, 11.52, 17.80 and 20.10 g per plant, respectively). It was followed by T<sub>2</sub>, during both years. During both years, T<sub>13</sub> resulted in the lowest DMP per plant at all stages of observation.

### **4.1.2 Physiological Parameters**

#### ***4.1.2.1 Leaf Area Index (LAI)***

Nutrient levels had significant influence on LAI of sesame during both years of study (Tables 10a and 10b).

At 20 DAS during 2021-22, T<sub>1</sub> (0.38) resulted in higher LAI and was on par with T<sub>2</sub> (0.29) and T<sub>4</sub> (0.27). While, during 2022-23, T<sub>2</sub> resulted in higher LAI (0.65) and was on par with T<sub>1</sub> (0.59).

At 40 DAS during 2021-22, higher LAI was noted in T<sub>1</sub> (3.85) and was on par with T<sub>2</sub> (3.53). During 2022-23, T<sub>1</sub> had higher LAI (4.28) and was on par with T<sub>2</sub> (4.19) and T<sub>4</sub> (3.96).

Table 6a. Plant height at 20 DAS and 40 DAS, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, cm

Treatments	2021-22		2022-23	
	20 DAS	40 DAS	20 DAS	40 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	30.3	86.3	31.5	91.6
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	28.1	80.6	30.7	88.7
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	23.6	63.0	24.2	74.1
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	26.1	73.1	27.8	78.3
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	21.4	57.5	24.8	69.6
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	22.4	57.7	20.3	68.0
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	26.4	75.5	26.5	81.1
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	24.4	64.3	25.1	71.8
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	25.5	67.4	24.3	68.7
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	25.2	71.0	23.8	72.8
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	25.4	78.6	26.6	75.0
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	24.0	61.8	24.7	67.0
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	17.3	49.4	20.0	59.1
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	25.6	65.2	24.0	70.6
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	25.0	66.1	25.5	69.7
SEm (±)	0.9	1.9	1.2	3.1
CD (p=0.05)	2.56	5.48	3.58	8.89

Table 6b. Plant height at 60 DAS and harvest, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, cm

Treatments	2021-22		2022-23	
	60 DAS	Harvest	60 DAS	Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	127.0	150.8	140.7	163.5
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	119.9	142.1	136.8	158.6
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	95.4	116.8	121.7	147.7
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	116.3	136.3	128.9	156.7
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	103.3	121.5	114.0	142.7
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	94.9	117.7	119.3	125.6
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	117.3	138.9	131.5	154.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	107.4	124.6	121.4	148.9
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	114.8	132.6	120.8	146.0
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	112.0	126.1	122.1	149.7
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	117.4	133.9	127.6	150.3
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	97.6	112.3	110.4	140.0
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	86.3	106.2	99.7	134.5
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	110.1	129.3	120.0	146.8
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	113.4	128.5	125.3	144.2
SEm (±)	2.6	2.9	2.5	2.7
CD (p=0.05)	7.54	8.72	7.27	7.85

Table 7a. Number of leaves at 20 DAS and 40 DAS, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23

Treatments	2021-22		2022-23	
	20 DAS	40 DAS	20 DAS	40 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	8.3	35.3	10.3	37.7
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	7.7	31.7	8.7	36.0
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	6.3	22.0	7.0	28.0
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	7.0	31.3	8.3	32.3
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	6.7	22.7	6.7	26.3
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	6.3	21.3	6.7	26.0
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	8.0	23.0	8.0	33.0
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	6.3	27.0	7.0	27.3
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	7.0	29.3	7.7	30.0
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	6.3	21.3	7.0	24.7
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	7.0	30.7	8.3	27.3
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	6.0	20.7	6.3	24.3
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	5.7	18.3	4.7	20.0
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	6.7	24.3	7.3	26.7
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	6.3	22.7	8.0	25.0
SEm (±)	0.3	0.9	0.6	1.3
CD (p=0.05)	0.96	2.82	1.65	3.75

Table 7b. Number of leaves at 60 DAS and harvest, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23

Treatments	2021-22		2022-23	
	60 DAS	Harvest	60 DAS	Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	74.3	43.0	83.3	32.0
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	67.7	36.0	75.0	30.3
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	45.7	29.3	57.3	27.7
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	65.7	38.4	70.3	31.3
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	56.7	32.0	61.0	29.7
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	45.3	25.0	54.3	26.3
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	64.3	36.3	69.0	32.0
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	52.0	33.0	59.3	31.0
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	52.3	30.3	61.0	26.7
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	48.0	31.3	56.3	26.3
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	67.0	36.3	74.7	30.0
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	47.0	29.3	59.0	27.7
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	37.3	24.3	46.7	23.3
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	47.7	30.0	53.7	32.7
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	46.3	31.0	55.0	26.3
SEm (±)	2.1	1.5	2.6	2.1
CD (p=0.05)	6.08	4.39	7.47	NS

Table 8a. Number of branches at 20 DAS and 40 DAS, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23

Treatments	2021-22		2022-23	
	20 DAS	40 DAS	20 DAS	40 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	1.0	5.7	1.3	6.0
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	1.0	4.7	1.0	5.0
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	1.0	3.7	1.0	4.0
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	1.0	4.0	1.0	4.7
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	1.0	3.7	1.0	3.7
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	1.0	3.3	1.0	4.0
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	1.0	3.7	1.0	3.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	1.0	3.7	1.0	3.7
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	1.0	3.3	1.3	4.3
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	1.0	3.0	1.0	3.3
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	1.0	3.3	1.0	3.7
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	1.0	2.3	1.0	2.7
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	1.0	2.0	1.0	2.0
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	1.0	3.7	1.0	4.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	1.0	2.7	1.0	3.7
SEm (±)	0.0	0.4	0.1	0.5
CD (p=0.05)	NS	1.26	NS	1.47

Table 8b. Number of branches at 60 DAS and harvest, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23

Treatments	2021-22		2022-23	
	60 DAS	Harvest	60 DAS	Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	8.3	9.0	9.3	10.0
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	8.0	8.7	8.7	10.7
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	5.3	5.7	6.0	6.3
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	4.7	6.3	6.7	7.3
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	4.3	5.0	4.7	6.0
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	3.0	4.7	5.0	6.3
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	4.7	5.3	5.3	7.0
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	5.3	5.7	6.0	6.7
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	6.7	7.0	5.7	7.0
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	5.3	6.7	7.3	7.7
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	6.0	7.3	6.0	7.3
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	3.7	4.3	4.3	5.3
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	2.3	3.7	3.0	4.0
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	4.3	5.3	4.7	6.0
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	5.0	5.7	5.0	6.3
SEm (±)	0.5	0.4	0.6	0.6
CD (p=0.05)	1.45	1.18	1.58	1.73

Table 9a. Dry matter production at 20 DAS and 40 DAS, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, g per plant

Treatments	2021-22		2022-23	
	20 DAS	40 DAS	20 DAS	40 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	1.12	9.92	1.27	11.52
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.97	8.90	1.04	9.73
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.81	7.95	0.82	8.23
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.93	8.77	0.96	9.41
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.73	7.67	0.79	8.17
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.66	6.97	0.69	7.23
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.89	8.71	0.94	9.10
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.76	7.89	0.79	8.40
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.81	8.01	0.85	8.33
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.62	6.03	0.71	6.47
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.89	8.63	0.89	8.93
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.56	5.10	0.65	6.17
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.45	4.38	0.50	5.41
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.70	7.42	0.76	8.13
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.68	7.30	0.73	7.84
SEm (±)	0.03	0.31	0.04	0.39
CD (p=0.05)	0.082	0.901	0.103	1.143

Table 9b. Dry matter production at 60 DAS and harvest, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, g per plant

Treatments	2021-22		2022-23	
	60 DAS	Harvest	60 DAS	Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	15.70	18.72	17.80	20.10
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	14.19	17.25	15.63	17.87
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	12.26	14.62	12.93	15.37
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	13.75	16.30	14.83	17.53
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	11.94	13.54	12.40	14.83
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	10.87	11.90	9.57	12.77
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	13.55	15.97	14.50	16.67
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	12.10	14.03	12.83	15.00
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	12.37	14.87	13.00	15.60
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	8.55	10.97	9.30	11.88
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	13.14	15.33	13.64	16.23
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	7.68	9.57	8.93	11.00
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	6.07	7.87	7.33	9.90
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	11.43	13.60	12.20	14.67
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	11.13	13.09	10.56	14.50
SEm (±)	0.35	0.46	0.37	0.31
CD (p=0.05)	1.008	1.336	1.082	0.906

At 60 DAS during 2021-22, T<sub>1</sub> resulted in higher LAI (5.57) and was on par with T<sub>2</sub> (5.25) and T<sub>4</sub> (5.02). During 2022-23 also, T<sub>1</sub> had higher LAI (6.04) but was on par with T<sub>2</sub> (5.89).

#### **4.1.2.3 Chlorophyll Content**

The data presented in Tables 11a and 11b showed variations in chlorophyll content at 20 DAS, 40 DAS and 60 DAS due to the effect of different nutrient levels during 2021-22 and 2022-23.

At 20 DAS nutrient levels had significant effect on chlorophyll content only during 2022-23. The treatment T<sub>1</sub> resulted in significantly higher chlorophyll content (0.82 mg g<sup>-1</sup> fresh weight) which was followed by T<sub>2</sub> and T<sub>4</sub>.

At 40 DAS, during 2021-22, T<sub>1</sub> resulted in higher chlorophyll content (1.62 mg g<sup>-1</sup> fresh weight) and was on par with T<sub>2</sub> (1.58 mg g<sup>-1</sup> fresh weight). While, during 2022-23, higher chlorophyll content was observed in T<sub>1</sub> (1.63 mg g<sup>-1</sup> fresh weight) and was on par with T<sub>4</sub> (1.61 mg g<sup>-1</sup> fresh weight) and T<sub>2</sub> (1.56 mg g<sup>-1</sup> fresh weight).

At 60 DAS nutrient levels had significant effect on chlorophyll content only during 2021-22. Among the treatments, T<sub>2</sub> had higher chlorophyll content (2.55 mg g<sup>-1</sup> fresh weight) and it was on par with T<sub>1</sub> (2.52 mg g<sup>-1</sup> fresh weight) and T<sub>4</sub> (2.50 mg g<sup>-1</sup> fresh weight).

The treatment T<sub>13</sub> resulted in lower chlorophyll content at all stages of observation, during both years.

#### **4.1.2.4 Crop Growth Rate (CGR)**

Significant difference in CGR at 20 DAS-40 DAS, 40 DAS-60 DAS and 60 DAS- harvest, due to nutrient levels are presented in Tables 12a and 12b.

During 2021-22, at time interval 20 DAS-40 DAS, higher CGR was recorded in T<sub>1</sub> (9.78 g m<sup>-2</sup> d<sup>-1</sup>) and was on par with T<sub>2</sub> (8.81 g m<sup>-2</sup> d<sup>-1</sup>). While, during 2022-23, T<sub>1</sub> resulted in significantly higher CGR (10.99 g m<sup>-2</sup> d<sup>-1</sup>).

At 40 DAS-60 DAS during both years, T<sub>1</sub> resulted in higher CGR (6.42 g m<sup>-2</sup> d<sup>-1</sup> and 6.90 g m<sup>-2</sup> d<sup>-1</sup>, respectively) and was on par with T<sub>2</sub> (5.88 g m<sup>-2</sup> d<sup>-1</sup> and 6.67 g m<sup>-2</sup> d<sup>-1</sup>, respectively), T<sub>4</sub> (5.53 g m<sup>-2</sup> d<sup>-1</sup> and 6.53 g m<sup>-2</sup> d<sup>-1</sup>, respectively) and T<sub>7</sub> (5.38 g m<sup>-2</sup> d<sup>-1</sup> and 5.69 g m<sup>-2</sup> d<sup>-1</sup>, respectively).

Nutrient levels had significant effect on CGR at 60 DAS-harvest only during 2021-22. The treatment, T<sub>1</sub> resulted in higher CGR (4.29 g m<sup>-2</sup> d<sup>-1</sup>) and was on par with T<sub>2</sub> (3.42 g m<sup>-2</sup> d<sup>-1</sup>) and T<sub>4</sub> (3.35 g m<sup>-2</sup> d<sup>-1</sup>).

#### **4.1.2.5 Relative Growth Rate (RGR)**

The data pertaining to the effect of different nutrient levels on RGR revealed that nutrient levels had significant effect on RGR at different time intervals (Tables 13a and 13b).

At 20 DAS-40 DAS during 2021-22, T<sub>1</sub> recorded higher RGR (0.129 g g<sup>-1</sup> d<sup>-1</sup>) and was on par with T<sub>2</sub> (0.120 g g<sup>-1</sup> d<sup>-1</sup>), T<sub>4</sub> (0.119 g g<sup>-1</sup> d<sup>-1</sup>), T<sub>7</sub> (0.118 g g<sup>-1</sup> d<sup>-1</sup>) and T<sub>11</sub> (0.117 g g<sup>-1</sup> d<sup>-1</sup>). While, the nutrient levels had no significant effect on RGR, during 2022-23.

At 40 DAS-60 DAS during both years, higher RGR was observed in T<sub>1</sub> (0.028 g g<sup>-1</sup> d<sup>-1</sup> and 0.030 g g<sup>-1</sup> d<sup>-1</sup>, respectively) and was on par with T<sub>2</sub> (0.025 g g<sup>-1</sup> d<sup>-1</sup> and 0.028 g g<sup>-1</sup> d<sup>-1</sup>, respectively), T<sub>4</sub> (0.023 g g<sup>-1</sup> d<sup>-1</sup> and 0.026 g g<sup>-1</sup> d<sup>-1</sup>, respectively), T<sub>7</sub> (0.022 g g<sup>-1</sup> d<sup>-1</sup> and 0.024 g g<sup>-1</sup> d<sup>-1</sup>, respectively) and T<sub>11</sub> (0.020 g g<sup>-1</sup> d<sup>-1</sup> and 0.023 g g<sup>-1</sup> d<sup>-1</sup>, respectively).

During both years, nutrient levels had no significant effect on RGR at time interval 60 DAS-harvest.

### **4.1.3 Yield and Yield Components**

#### **4.1.3.1 Days to 50 Per cent Flowering**

Days to 50 per cent flowering was not significantly influenced by different nutrient levels during 2021-22 and 2022-23.

#### **4.1.3.2 Number of Capsules per Plant**

During both years nutrient levels significantly influenced the number of capsules per plant (Table 14).

Table 10a. Leaf area index at 20 DAS, 40 DAS and 60 DAS, as influenced by nutrient levels during *Rabi* 2021-22

Treatments	2021-22		
	20 DAS	40 DAS	60 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.38	3.85	5.57
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.29	3.53	5.25
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.20	1.92	3.17
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.27	3.23	5.02
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.18	1.62	3.16
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.22	1.55	2.68
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.26	2.38	4.69
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.21	2.73	3.87
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.25	2.69	3.65
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.24	2.13	3.62
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.26	3.09	4.79
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.16	1.39	2.45
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.14	1.25	2.27
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.18	2.13	3.25
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.19	1.73	2.89
SEm (±)	0.04	0.16	0.23
CD (p=0.05)	0.107	0.472	0.657

Table 10b. Leaf area index at 20 DAS, 40 DAS and 60 DAS as influenced by nutrient levels during *Rabi* 2022-23

Treatments	2022-23		
	20 DAS	40 DAS	60 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.59	4.28	6.04
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.65	4.19	5.89
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.30	3.06	4.17
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.41	3.96	5.22
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.27	2.10	3.96
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.24	2.31	3.45
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.41	3.38	5.06
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.29	3.73	4.36
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.26	3.42	4.25
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.28	2.94	4.08
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.37	3.37	4.72
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.29	2.52	3.91
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.20	1.87	3.27
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.31	3.49	4.42
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.32	3.06	3.97
SEm (±)	0.03	0.19	0.21
CD (p=0.05)	0.076	0.539	0.620

Table 11a. Total chlorophyll content at 20 DAS, 40 DAS and 60 DAS as influenced by nutrient levels during *Rabi* 2021-22, mg g<sup>-1</sup> fresh weight

Treatments	2021-22		
	20 DAS	40 DAS	60 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.81	1.62	2.52
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.75	1.58	2.55
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.57	1.36	2.37
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.71	1.54	2.50
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.51	1.28	2.29
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.45	1.15	2.18
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.69	1.49	2.48
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.54	1.32	2.33
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.61	1.45	2.41
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.40	1.11	2.15
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.64	1.44	2.44
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.37	1.07	2.12
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.31	1.00	2.04
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.49	1.24	2.25
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.45	1.19	2.22
SEm (±)	0.01	0.02	0.02
CD (p=0.05)	NS	0.054	0.055

Table 11b. Total chlorophyll content at 20 DAS, 40 DAS and 60 DAS as influenced by nutrient levels during *Rabi* 2022-23, mg g<sup>-1</sup> fresh weight

Treatments	2022-23		
	20 DAS	40 DAS	60 DAS
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.82	1.63	2.53
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.75	1.56	2.56
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.59	1.36	2.29
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.72	1.61	2.50
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.52	1.30	2.30
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.45	1.17	2.19
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.69	1.49	1.84
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.56	1.32	2.34
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.61	1.45	2.42
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.41	1.13	2.16
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.65	1.48	2.53
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.38	1.13	2.14
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.32	1.01	2.05
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.49	1.26	2.29
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.45	1.20	2.25
SEm (±)	0.01	0.03	0.18
CD (p=0.05)	0.042	0.084	NS

Table 12a. Crop growth rate as influenced by nutrient levels during *Rabi* 2021-22,  $\text{g m}^{-2} \text{d}^{-1}$

Treatments	2021-22		
	20 DAS - 40 DAS	40 DAS - 60 DAS	60 DAS - Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	9.78	6.42	4.29
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	8.81	5.88	3.42
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	7.94	4.79	2.62
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	8.71	5.53	3.35
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	7.72	4.74	1.77
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	7.01	4.33	1.63
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	8.68	5.38	2.83
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	7.93	4.67	2.15
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	7.99	4.84	2.78
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	6.02	2.80	2.68
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	8.61	5.00	2.44
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	5.04	2.86	2.10
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	4.37	1.88	0.90
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	7.46	4.46	2.41
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	7.36	4.26	3.09
SEm ( $\pm$ )	0.34	0.49	0.39
CD (p=0.05)	0.980	1.407	1.135

Table 12b. Crop growth rate as influenced by nutrient levels during *Rabi* 2022-23,  $\text{g m}^{-2} \text{d}^{-1}$

Treatments	2022-23		
	20 DAS - 40 DAS	40 DAS - 60 DAS	60 DAS - Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	10.99	6.90	1.85
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	9.35	6.67	2.67
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	8.13	5.06	1.60
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	8.56	6.53	2.14
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	6.82	5.11	2.54
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	6.41	3.52	3.31
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	8.79	5.69	2.15
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	7.92	4.46	2.89
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	7.96	5.02	2.11
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	8.21	4.44	2.54
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	9.26	5.08	1.58
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	8.52	4.17	1.96
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	5.36	2.84	1.80
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	8.14	4.86	2.14
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	8.47	4.96	2.04
SEm ( $\pm$ )	0.45	0.74	0.46
CD (p=0.05)	1.054	1.759	NS

Table 13a. Relative growth rate as influenced by nutrient levels during *Rabi* 2021-22, g g<sup>-1</sup> d<sup>-1</sup>

Treatments	2021-22		
	20 DAS - 40 DAS	40 DAS - 60 DAS	60 DAS - Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.129	0.028	0.014
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.120	0.025	0.010
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.114	0.016	0.007
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.119	0.023	0.009
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.112	0.015	0.005
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.116	0.012	0.004
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.118	0.022	0.008
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.115	0.013	0.006
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.114	0.019	0.005
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.112	0.014	0.007
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.117	0.020	0.011
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.111	0.010	0.003
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.110	0.007	0.002
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.115	0.012	0.005
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.113	0.011	0.004
SEm (±)	0.004	0.003	0.002
CD (p=0.05)	0.0120	0.0080	NS

Table 13b. Relative growth rate as influenced by nutrient levels during *Rabi* 2022-23, g g<sup>-1</sup> d<sup>-1</sup>

Treatments	2022-23		
	20 DAS - 40 DAS	40 DAS - 60 DAS	60 DAS - Harvest
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.126	0.030	0.016
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.124	0.028	0.015
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.115	0.022	0.008
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.124	0.026	0.006
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.123	0.021	0.009
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.117	0.020	0.014
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.121	0.024	0.007
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.116	0.019	0.010
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.115	0.018	0.011
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.113	0.016	0.008
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.120	0.023	0.005
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.111	0.013	0.003
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.110	0.011	0.002
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.119	0.015	0.007
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.118	0.014	0.006
SEm (±)	0.003	0.003	0.002
CD (p=0.05)	NS	0.0072	NS

Among the treatments, T<sub>1</sub> resulted in the greatest number of capsules per plant during both years (57.7 and 74.7, respectively). The lowest number of capsules per plant was noted in T<sub>13</sub> during both years.

#### **4.1.3.3 Number of Seeds per Capsule**

Perusal of the data on number of seeds per capsule in Table 15 revealed that number of seeds per capsule were significantly influenced by nutrient levels.

The treatment, T<sub>1</sub> produced greater number of seeds per capsule during both years (60.7 and 60.3, respectively). However, it was on par with T<sub>2</sub> (58.0) during 2021-22 and with T<sub>2</sub> and T<sub>4</sub> (59.3 and 55.3, respectively) during 2022-23. The treatment T<sub>13</sub> resulted in the lowest number of seeds per capsule during both years.

#### **4.1.3.4 Hundred Seed Weight**

Nutrient levels did not exert any significant effect on hundred seed weight of sesame.

#### **4.1.3.5 Seed Yield per Plant**

Perusal of the data on seed yield per plant in Table 16 revealed that seed yield per plant differed significantly with the nutrient levels.

During 2021-22 and 2022-23, the highest seed yield per plant was observed in T<sub>1</sub> (9.2 g and 12.6 g, respectively) and the lowest seed yield per plant was noted in T<sub>13</sub>.

#### **4.1.3.6 Seed Yield ha<sup>-1</sup>**

Seed yield ha<sup>-1</sup> was significantly influenced by nutrient levels (Table 17).

Among the nutrient levels, T<sub>1</sub> resulted in the highest seed yield during 2021-22 and 2022-23 (503.5 kg ha<sup>-1</sup> and 554.7 kg ha<sup>-1</sup>, respectively) and was followed by T<sub>2</sub>. During both years, T<sub>13</sub> resulted in the lowest seed yield ha<sup>-1</sup> (248.9 kg ha<sup>-1</sup> and 287.8 kg ha<sup>-1</sup>, respectively).

The pooled data of 2021-22 and 2022-23 revealed that seed yield was significantly influenced by nutrient levels and the highest seed yield was observed in T<sub>1</sub> (529.1 kg ha<sup>-1</sup>) and the lowest seed yield in T<sub>13</sub> (268.4 kg ha<sup>-1</sup>).

Tables 18, 19, 20, 21, 21a 22, 22a 23, 24 and 24a showed the results obtained by the statistical analyses of data on seed yield using CCD. The effect of different nutrient levels and the respective seed yield of sesame, during both seasons were fitted to a second order model ( $Y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \beta_3x_3 + \beta_{11}x_1^2 + \beta_{22}x_2^2 + \beta_{33}x_3^2 + \beta_{12}x_1x_2 + \beta_{13}x_1x_3 + \beta_{23}x_2x_3$  where  $\beta_0$  was the intercept,  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  were the coefficient of  $x_1$ ,  $x_2$  and  $x_3$ ,  $\beta_{11}$ ,  $\beta_{22}$ ,  $\beta_{33}$  and  $\beta_{12}$ ,  $\beta_{13}$ ,  $\beta_{23}$  were the quadratic and interactive regression coefficients, respectively) and the goodness of fit was examined. Analysis of variance was performed to understand the significance of linear, quadratic and two-way interactions of different nutrients levels on the seed yield.

Since the eigen values during *Rabi* 2021-22 and 2022-23 were 40.979438, 21.742420 and -9.368968 and 43.388813, 22.401428 and -4.160918 respectively, stationary points were saddle points. Canonical path analysis was performed, starting at the saddle point and following the most steeply rising ridge in both directions. During *Rabi* 2021-22 and *Rabi* 2022-23, optimum NPK doses were obtained from the canonical path analysis. Two nutrient levels were selected during *Rabi* 2021-22 viz., 35:26:7 kg NPK ha<sup>-1</sup> and 34:21:3 kg NPK ha<sup>-1</sup> (Table 21a) and one optimum NPK level was selected during *Rabi* 2022-23 viz., 34:35:3 kg NPK ha<sup>-1</sup> (Table 24a), based on the estimated yield and negative values for  $x_1$ ,  $x_2$  and  $x_3$ . The results were validated in the second experiment, during *Rabi* 2023-24 to determine the best NPK level for sesame in Southern Laterites.

#### **4.1.3.7 Haulm Yield per Plant**

Significant difference in haulm yield per plant was observed among the treatments due to nutrient levels.

During 2021-22 and 2022-23, T<sub>1</sub> resulted in higher haulm yield per plant (22.8 g and 26.2 g, respectively) and was on par with T<sub>2</sub> (21.9 g and 24.5 g, respectively). The lowest haulm yield per plant was observed in T<sub>13</sub> during both years.

#### **4.1.3.8 Haulm Yield ha<sup>-1</sup>**

The nutrient levels had significant influence on haulm yield ha<sup>-1</sup> of sesame during 2021-22 and 2022-23 (Table 17).

Perusal of data on haulm yield ha<sup>-1</sup> revealed that T<sub>1</sub> produced higher haulm yield (2626 kg ha<sup>-1</sup> and 2751 kg ha<sup>-1</sup>) and was on par with T<sub>2</sub> (2581 kg ha<sup>-1</sup> and 2641 kg ha<sup>-1</sup>), during both years. While, the lowest haulm yield ha<sup>-1</sup> were observed in T<sub>13</sub> during both years.

#### **4.1.3.9 Harvest Index (HI)**

Harvest index was significantly influenced by nutrient levels during both years.

During both years, T<sub>1</sub> resulted in Higher HI (0.161 and 0.180, respectively) and was on par with T<sub>2</sub> (0.152 and 0.162, respectively). The lowest HI was noted in T<sub>13</sub> during both years.

#### **4.1.4 Quality Parameters**

The data pertaining to the effect of different nutrient levels on the quality parameters of sesame are presented in Tables 26, 27, 28 and 29.

##### **4.1.4.1 Oil Content**

Among the nutrient levels, the highest oil content was observed in T<sub>1</sub> (42.13%), during 2021-22 and the lowest in T<sub>13</sub>. While the effect of nutrients on oil content was non-significant during 2022-23.

##### **4.1.4.2 Crude Protein Content**

The data on the effect of nutrient levels on crude protein content of sesame seed is presented in Table 26.

Perusal of the data revealed that among the treatments, higher crude protein content of sesame was observed in T<sub>1</sub> (23.13%) which was on par with T<sub>2</sub> (22.63%) during 2021-22. However, during 2022-23, T<sub>2</sub> resulted in higher crude protein

Table 14. Days to 50 per cent flowering and number of capsules per plant as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23

Treatments	2021-22		2022-23	
	Days to 50 per cent flowering	Number of capsules per plant	Days to 50 per cent flowering	Number of capsules per plant
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	36.0	57.7	37.0	74.7
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	37.0	53.0	36.7	64.7
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	37.0	50.0	37.0	56.0
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	37.3	52.0	36.7	64.3
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	37.3	47.0	36.3	55.7
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	37.0	44.0	36.3	54.0
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	37.0	51.3	36.7	61.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	38.0	46.3	36.3	60.3
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	37.3	49.0	38.7	57.0
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	37.7	44.7	35.7	58.7
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	37.3	48.7	37.7	61.7
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	37.3	39.0	39.0	58.0
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	38.0	37.0	36.7	50.3
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	37.7	46.0	35.7	58.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	37.0	44.3	35.7	60.0
SEm (±)	0.8	1.2	0.8	3.3
CD (p=0.05)	NS	3.54	NS	9.66

Table 15. Number of seeds per capsule and 100 seed weight, as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23

Treatments	2021-22		2022-23	
	Number of seeds per capsule	100 seed weight (g)	Number of seeds per capsule	100 seed weight (g)
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	60.7	0.29	60.3	0.28
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	58.0	0.27	59.3	0.28
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	53.3	0.27	52.0	0.27
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	51.7	0.28	55.3	0.27
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	47.0	0.27	48.0	0.27
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	44.0	0.28	46.3	0.27
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	49.7	0.28	53.3	0.27
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	46.3	0.28	45.7	0.25
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	45.7	0.26	44.7	0.27
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	49.0	0.28	48.0	0.26
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	54.7	0.27	52.0	0.28
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	37.3	0.27	40.0	0.27
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	36.7	0.27	38.0	0.27
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	44.0	0.28	51.7	0.28
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	44.3	0.28	47.3	0.28
SEm (±)	1.1	0.01	2.3	0.01
CD (p=0.05)	3.05	NS	6.57	NS

Table 16. Seed and haulm yield per plant as influenced by nutrient levels during  
*Rabi* 2021-22 and 2022-23, g

Treatments	2021-22		2022-23	
	Seed yield	Haulm yield	Seed yield	Haulm yield
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	9.2	22.8	12.6	26.2
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	8.4	21.9	10.3	24.5
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	4.6	19.1	8.0	22.5
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	7.9	20.7	8.4	23.4
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	6.0	20.3	7.3	22.9
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	5.4	19.6	6.7	21.3
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	7.7	20.4	8.6	22.3
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	5.9	19.9	7.5	22.1
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	6.2	20.5	7.2	21.0
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	6.1	18.7	7.1	22.6
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	7.3	19.5	9.0	23.2
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	4.0	18.9	6.5	20.2
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	3.8	16.6	5.2	18.7
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	5.6	19.2	7.8	22.2
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	5.5	19.0	7.0	21.4
SEm (±)	0.2	0.4	0.7	0.7
CD (p=0.05)	0.69	1.12	2.04	2.02

Table 17. Seed yield and haulm yield as influenced by nutrient levels during  
Rabi 2021-22 and 2022-23, kg ha<sup>-1</sup>

Treatments	2021-22		2022-23		Pooled seed yield
	Seed yield	Haulm yield	Seed yield	Haulm yield	
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	503.5	2626	554.7	2751	529.1
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	483.1	2581	500.6	2641	492.4
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	331.0	2234	379.6	2338	355.3
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	415.9	2370	464.9	2442	440.4
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	319.1	2291	352.0	2242	335.6
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	290.3	2133	326.7	2138	308.5
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	405.5	2301	427.8	2486	416.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	330.1	2197	373.6	2225	351.9
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	350.5	2336	387.2	2174	368.9
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	287.7	1935	335.8	2295	311.8
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	398.5	2341	412.7	2435	405.6
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	281.1	1939	337.1	2154	309.1
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	248.9	1907	287.8	1979	268.4
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	309.3	2034	331.3	2233	320.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	293.0	2053	345.7	2244	319.4
SEm (±)	6.6	86	14.6	69	4.8
CD (p=0.05)	19.17	250.8	42.31	199.5	14.4

Table 18. Central composite design with coded values of independent variables and experimental result of response variables during *Rabi* 2021-22

Runs	Blk	Variable levels			Responses
		N	P	K	Yield
1	1	-1	-1	-1	1435.5
2	1	1	-1	-1	1427.3
3	1	-1	1	-1	1367.3
4	1	1	1	-1	1413.0
5	1	-1	-1	1	1204.8
6	1	1	-1	-1	1307.6
7	1	-1	1	1	1373.2
8	1	1	1	1	1367.2
9	1	-1.67	0	0	1331.9
10	1	1.67	0	0	1347.8
11	1	0.03	-1.67	0	1307.5
12	1	0.03	1.67	0	1264.8
13	1	0.03	0	-1.67	1336.8
14	1	0.03	0	1.67	1320.4
15	1	0.03	0	0	1305.5
16	1	0.03	0	0	1284.3
17	1	0.03	0	0	1307.5
18	1	0.03	0	0	1350.3
19	1	0.03	0	0	1307.6
20	1	0.03	0	0	1270.9
21	2	-1	-1	-1	2508.9
22	2	1	-1	-1	2472.8
23	2	-1	1	-1	2327.4
24	2	1	1	-1	2406.7
25	2	-1	-1	1	2224.6
26	2	1	-1	1	2274.5
27	2	-1	1	1	2349.9
28	2	1	1	1	2353.8
29	2	-1.67	0	0	2275.2
30	2	1.67	0	0	2344.1
31	2	0	-1.67	0	2293.7
32	2	0	1.67	0	2245.1
33	2	0	0	-1.67	2323.4
34	2	0	0	-1.67	2255.5
35	2	0	0	0	2282.4

36	2	0	0	0	2287.8
37	2	0	0	0	2239.0
38	2	0	0	0	2251.0
39	2	0	0	0	2283.0
40	2	0	0	0	2254.6
41	3	-1	-1	-1	3532.3
42	3	1	-1	-1	3435.0
43	3	-1	1	-1	3302.4
44	3	1	1	-1	3409.9
45	3	-1	-1	-1	3259.7
46	3	1	-1	1	3261.0
47	3	-1	1	1	3331.5
48	3	1	1	1	3300.5
49	3	-1.67	0	0	3258.5
50	3	1.67	0	0	3300.9
51	3	0.03	-1.67	0	3300.6
52	3	0.03	-1.67	0	3209.9
53	3	0.03	0	-1.67	3300.1
54	3	0.03	0	1.67	3351.0
55	3	0.03	0	0	3263.9
56	3	0.03	0	0	3286.0
57	3	0.03	0	0	3303.3
58	3	0.03	0	0	3265.6
59	3	0.03	0	0	3265.3
60	3	0.03	0	0	3337.8

Table 19. Response surface second order regression analysis during *Rabi* 2021-22

Term	Estimate	Std. error	T value	P value
Intercept	300.8047	19.4688	15.4506	2.2e-16 ***
blk	-8.9000	7.8080	-1.1399	0.259888
N	10.1474	7.7434	1.3105	0.196152
P	-8.5663	7.7448	-1.1061	0.274093
K	-36.5619	7.7448	-4.7209	2.001e-05 ***
N:P	7.5841	10.0782	0.7525	0.455336
N:K	1.9479	10.0782	0.1933	0.847542
P:K	47.0417	10.0801	4.6668	2.400e-05***
N <sup>2</sup>	22.0181	7.6165	2.8908	0.005712**
P <sup>2</sup>	7.6994	7.6123	1.0114	0.316773
K <sup>2</sup>	23.6354	7.6123	3.1049	0.003160**

Table 20. ANOVA for the fit of experimental data to response surface model during *Rabi* 2021-22

	Df	Sum Sq	Mean Sq	F value	P value (> F)
FO( $x_1, x_2, x_3$ )	3	61059	20353.1	8.3462	0.0001387
TW( $x_1, x_2, x_3$ )	3	54582	18194.0	7.4608	0.0003282
PQ( $x_1, x_2, x_3$ )	3	40879	13626.5	5.5878	0.0022338
Residuals	49	119492	2438.6		

\*Multiple R-squared: 0.572 Adjusted R-squared: 0.4846

Table 21. Canonical analysis to determine the optimum N, P and K for sesame in Southern Laterites during *Rabi* 2021-22

	Dist.	$x_1$	$x_2$	$x_3$	N	P	K	Yield
1	-5.0	0.416	3.728	3.963	54	91	67	1302
2	-4.5	0.338	3.437	3.564	53	87	57	1108
3	-4.0	0.259	3.146	3.165	52	82	53	934
4	-3.5	0.180	2.855	2.766	50	78	50	780
5	-3.0	0.102	2.565	2.367	49	73	46	647
6	-2.5	0.023	2.274	1.969	48	69	43	534
7	-2.0	-0.056	1.983	1.570	47	65	39	442
8	-1.5	-0.134	1.692	1.171	45	60	36	370
9	-1.0	-0.213	1.401	0.772	44	56	32	319
10	-0.5	-0.292	1.110	0.373	43	52	28	288
11	0.0	-0.370	-0.819	0.026	41	47	25	278
12	0.5	-0.449	-0.528	0.425	40	43	21	288
13	1.0	-0.528	0.237	0.824	-38	39	18	319
14	1.5	-0.606	-0.054	-1.223	37	34	14	370
15	2.0	-0.685	-0.345	-1.622	36	30	10	442
<b>16</b>	<b>2.5</b>	<b>-0.764</b>	<b>-0.636</b>	<b>-2.021</b>	<b>35</b>	<b>26</b>	<b>7</b>	<b>534</b>
<b>17</b>	<b>3.0</b>	<b>-0.842</b>	<b>-0.927</b>	<b>-2.420</b>	<b>34</b>	<b>21</b>	<b>3</b>	<b>647</b>
18	3.5	-0.921	-1.218	-2.819	32	17	-0.371	780
19	4.0	-1.000	-1.508	-3.218	31	12	-3.962	933
20	4.5	-1.078	-1.799	-3.617	30	8	-7.553	1107

Table 21a. Optimum N, P and K levels during *Rabi* 2021-22

N (kg ha <sup>-1</sup> )	P (kg ha <sup>-1</sup> )	K (kg ha <sup>-1</sup> )
35	26	7
34	21	3

Table 22. Central composite design with coded values of independent variables and experimental result of response variables during *Rabi* 2022-23

Runs	Blk	Variable levels			Responses
		N	P	K	Yield
1	1	-1	-1	-1	1532.0
2	1	1	-1	-1	1508.0
3	1	-1	1	-1	1358.9
4	1	1	1	-1	1424.7
5	1	-1	-1	1	1311.6
6	1	1	-1	-1	1310.9
7	1	-1	1	1	1401.5
8	1	1	1	1	1395.9
9	1	-1.67	0	0	1320.1
10	1	1.67	0	0	1350.0
11	1	0.03	-1.67	0	1301.3
12	1	0.03	1.67	0	1225.8
13	1	0.03	0	-1.67	1324.2
14	1	0.03	0	1.67	1308.0
15	1	0.03	0	0	1300.0
16	1	0.03	0	0	1281.2
17	1	0.03	0	0	1301.2
18	1	0.03	0	0	1291.9
19	1	0.03	0	0	1283.2
20	1	0.03	0	0	1293.0
21	2	-1	-1	-1	2498.2
22	2	1	-1	-1	2449.1
23	2	-1	1	-1	2368.2
24	2	1	1	-1	2426.9
25	2	-1	-1	1	2266.7
26	2	1	-1	1	2306.6
27	2	-1	1	1	2383.5
28	2	1	1	1	2366.0
29	2	-1.67	0	0	2305.0
30	2	1.67	0	0	2331.0
31	2	0	-1.67	0	2335.5
32	2	0	1.67	0	2258.9
33	2	0	0	-1.67	2331.4
34	2	0	0	-1.67	2336.2
35	2	0	0	0	2299.2

36	2	0	0	0	2298.7
37	2	0	0	0	2290.8
38	2	0	0	0	2296.0
39	2	0	0	0	2301.4
40	2	0	0	0	2301.4
41	3	-1	-1	-1	3556.6
42	3	1	-1	-1	3401.2
43	3	-1	1	-1	3372.1
44	3	1	1	-1	3442.3
45	3	-1	-1	-1	3204.1
46	3	1	-1	1	3300.9
47	3	-1	1	1	3357.8
48	3	1	1	1	3308.2
49	3	-1.67	0	0	3310.1
50	3	1.67	0	0	3338.8
51	3	0.03	-1.67	0	3353.0
52	3	0.03	-1.67	0	3300.0
53	3	0.03	0	-1.67	3329.0
54	3	0.03	0	1.67	3372.0
55	3	0.03	0	0	3305.9
56	3	0.03	0	0	3308.5
57	3	0.03	0	0	3311.2
58	3	0.03	0	0	3319.3
59	3	0.03	0	0	3322.8
60	3	0.03	0	0	3312.8

Table 22a. Response surface second order regression analysis during *Rabi* 2022-23

Term	Estimate	Std. error	T value	P value
Intercept	298.0326	20.0566	14.8596	< 2.2e-16 ***
blk	0.0725	8.0437	0.0090	0.9928452
N	3.8985	7.9772	0.4887	0.0627304
P	-9.4949	7.9786	-1.1901	0.2397598
K	-33.7935	7.9786	-4.2355	0.0001001 ***
N:P	8.7002	10.3825	0.8380	0.4061194
N:K	4.8204	10.3825	0.4643	0.6445019
P:K	44.3375	10.3844	4.2696	8.955e-05 ***
N <sup>2</sup>	23.2654	7.8465	2.9651	0.0046642 **
P <sup>2</sup>	12.3930	7.8421	1.5803	0.1204700
K <sup>2</sup>	25.9710	7.8421	3.3117	0.0017466 **

Table 23. ANOVA for the fit of experimental data to response surface model, during *Rabi* 2022-23

	Df	Sum Sq	Mean Sq	F value	P value (> F)
FO( $x_1, x_2, x_3$ )	3	50342	16780.7	6.4838	0.0008778
TWI( $x_1, x_2, x_3$ )	3	49555	16518.2	6.3824	0.0009741
PQ( $x_1, x_2, x_3$ )	3	49829	16609.5	6.4177	0.0009394
Residuals	49	126816	2588.1		

\*Multiple R-squared: 0.5414, Adjusted R-squared: 0.4478

Table 24. Canonical analysis to determine the optimum N, P and K for sesame in Southern Laterites during *Rabi* 2022-23.

	Dist.	$x_1$	$x_2$	$x_3$	N	P	K	Yield
1	-5.0	0.811	4.318	3.392	61	100	56	1384
2	-4.5	0.701	4.025	3.003	59	95	52	1178
3	-4.0	0.591	3.731	2.614	57	91	49	994
4	-3.5	0.481	3.437	2.224	55	87	45	831
5	-3.0	0.371	3.143	1.835	54	82	42	690
6	-2.5	0.261	2.849	1.446	52	78	38	570
7	-2.0	0.151	2.555	1.057	50	73	35	473
8	-1.5	0.040	2.261	0.667	48.	69	31	397
9	-1.0	-0.070	1.968	0.278	46	64	28	343
10	-0.5	-0.180	1.674	-0.111	45	60	24	310
11	0.0	-0.290	1.380	-0.500	43	56	21	299
12	0.5	-0.400	1.086	-0.890	41	51	17	310
13	1.0	-0.510	0.792	-1.279	39	47	13	343
14	1.5	0.498	-0.620	-1.668	37	42	10	397
15	2.0	-0.731	0.204	-2.057	35	38	6	473
<b>16</b>	<b>2.5</b>	<b>-0.841</b>	<b>-0.089</b>	<b>-2.447</b>	<b>34</b>	<b>35</b>	<b>3</b>	<b>570</b>
17	3.0	-0.951	-0.383	-2.836	32	29	-1	690
18	3.5	-1.061	-0.677	-3.225	30	25	-4	831
19	4.0	-1.171	-0.971	-3.614	28	20	-8	994
20	4.5	-1.281	-1.265	-4.004	26	16	-11	1178

Table 24a. Optimum N, P and K level during *Rabi* 2022-23

N (kg ha <sup>-1</sup> )	P (kg ha <sup>-1</sup> )	K (kg ha <sup>-1</sup> )
34	35	3

Table 25. Harvest Index as influenced by nutrient levels during *Rabi* 2021-22 and *Rabi* 2022-23

Treatments	2021-22	2022-23
	Harvest Index	Harvest Index
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.161	0.180
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.152	0.162
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.129	0.145
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.146	0.152
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.122	0.136
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.120	0.133
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.145	0.154
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.131	0.144
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.130	0.151
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.129	0.128
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.146	0.156
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.127	0.135
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.116	0.127
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.132	0.129
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.125	0.133
SEm (±)	0.004	0.007
CD (p=0.05)	0.0100	0.0190

content (25.24%) which was on par with T<sub>1</sub> (25.13%) and T<sub>4</sub> (24.44%). During both years, the lowest crude protein content was observed in T<sub>13</sub>.

#### ***4.1.4.3 Phosphorus (P) Content***

The data presented in Table 27, showed variation in P content of sesame seeds due to the application of different levels of N, P and K.

During 2021-22 and 2022-23, T<sub>2</sub> resulted in higher P content of sesame seeds (0.440% and 0.390%, respectively) which was on par with T<sub>1</sub> (0.417% and 0.357%, respectively) and T<sub>4</sub> (0.397% and 0.347%, respectively). The treatment T<sub>13</sub> resulted in the lowest P content of sesame seeds.

#### ***4.1.4.4 Calcium (Ca) Content***

Table 27, illustrated the effect of nutrient levels on Ca content of sesame seeds. The Ca content of sesame seeds was non-significant during 2021-22. During 2022-23, T<sub>1</sub> resulted in higher Ca content (0.491%) which was on par with T<sub>2</sub> (0.429%). The lowest Ca content was observed in T<sub>13</sub>.

#### ***4.1.4.5 Magnesium (Mg) Content***

Nutrient levels had significant influence on Mg content of sesame seeds (Table 28). During 2021-22, Mg content was higher in T<sub>2</sub> (0.554%) which was on par with T<sub>1</sub> (0.499%). While, during 2022-23, T<sub>2</sub> had higher Mg content (0.329%) which was on par with T<sub>1</sub> (0.326%) and T<sub>4</sub> (0.289%). The treatment T<sub>13</sub> resulted in the lowest Mg content of sesame seeds during both years.

#### ***4.1.4.6 Iron (Fe) Content***

Similar to that of Mg content, nutrient levels had significant effect on Fe content of sesame seeds. Among the nutrient levels, T<sub>2</sub> resulted in higher Fe content (0.036% and 0.049%, respectively) which was on par with T<sub>1</sub> (0.033% and 0.045%, respectively), during both years. The lowest Fe content was observed in T<sub>13</sub> during both years (0.006 % and 0.014%, respectively).

#### **4.1.4.7 Zinc (Zn) Content**

The results in Table 29 depicted the effect of nutrient levels on Zn content. During 2021-22, T<sub>1</sub> (0.025%) resulted in higher Zn content which was on par with T<sub>2</sub> (0.023%) and T<sub>4</sub> (0.022%). However, during 2022-23, the result was non-significant.

#### **4.1.5 Plant Analysis**

The effect of nutrient levels on N, P and K uptake by sesame are given in Tables 30, 31, 32, 33, 34 and 35.

##### **4.1.6.1 N Uptake**

Perusal of the data on N uptake by seed, haulm and total uptake (Tables 30 and 31) revealed that uptake of N by seed, haulm and total uptake were higher in T<sub>1</sub>, (33.0 kg ha<sup>-1</sup>, 37.0 kg ha<sup>-1</sup> and 70.0 kg ha<sup>-1</sup>, respectively) and was on par with T<sub>2</sub> (32.0 kg ha<sup>-1</sup>, 35.7 kg ha<sup>-1</sup> and 67.7 kg ha<sup>-1</sup>, respectively), during 2021-22. While, during 2022-23, higher N uptake by seed was observed in T<sub>1</sub> (37.2 kg ha<sup>-1</sup>) which was on par with T<sub>2</sub> (35.7 kg ha<sup>-1</sup>). However, N uptake by haulm and the total uptake were significantly the highest in T<sub>1</sub> (41.8 kg ha<sup>-1</sup> and 79.0 kg ha<sup>-1</sup>, respectively). During both years T<sub>13</sub> resulted in the lowest N uptake by seed, haulm and total uptake.

##### **4.1.6.2 P Uptake**

As depicted in Tables 32 and 33, P uptake varied significantly with nutrient levels.

During 2021-22, T<sub>1</sub> resulted in higher P uptake by seed (3.6 kg ha<sup>-1</sup>) which was on par with T<sub>2</sub> (3.5 kg ha<sup>-1</sup>) and T<sub>7</sub> (3.3 kg ha<sup>-1</sup>). While, P uptake by haulm and total P uptake were significantly higher in T<sub>1</sub> (8.6 kg ha<sup>-1</sup> and 12.2 kg ha<sup>-1</sup>, respectively). During 2022-23, P uptake by seed and total uptake were significantly higher in T<sub>1</sub> (4.6 kg ha<sup>-1</sup> and 14.9 kg ha<sup>-1</sup>, respectively). While, P uptake by haulm was higher in T<sub>1</sub> (10.3 kg ha<sup>-1</sup>) and was on par with T<sub>2</sub> (9.7 kg ha<sup>-1</sup>) and T<sub>4</sub> (9.6 kg ha<sup>-1</sup>).

Table 26. Oil and crude protein content in sesame seeds as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, %

Treatments	2021-22		2022-23	
	Oil content	Crude Protein	Oil content	Crude protein
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	42.13	23.13	40.53	25.13
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	40.90	22.63	39.63	25.24
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	39.57	18.67	40.77	22.57
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	40.93	21.70	40.80	24.44
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	39.73	18.17	40.90	22.07
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	39.77	16.30	40.87	20.80
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	40.70	20.83	39.37	24.00
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	39.37	18.08	40.23	22.57
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	39.46	19.50	41.37	23.20
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	39.80	16.00	40.33	19.63
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	40.13	20.13	39.90	23.73
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	40.30	15.47	40.10	18.67
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	38.17	14.67	39.90	17.48
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	40.33	17.53	40.77	21.87
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	40.73	16.90	40.20	21.50
SEm (±)	0.41	0.31	0.46	0.32
CD (p=0.05)	1.185	0.885	NS	0.938

Table 27. Phosphorus and calcium content in sesame seeds as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, %

Treatments	2021-22		2022-23	
	P	Ca	P	Ca
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.417	0.433	0.357	0.491
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.440	0.340	0.390	0.429
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.300	0.333	0.280	0.303
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.397	0.417	0.347	0.386
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.357	0.347	0.237	0.276
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.207	0.345	0.227	0.241
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.367	0.390	0.313	0.374
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.280	0.367	0.260	0.277
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.320	0.300	0.300	0.314
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.205	0.357	0.243	0.219
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.343	0.317	0.277	0.338
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.173	0.277	0.220	0.203
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.170	0.273	0.177	0.187
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.243	0.267	0.233	0.261
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.230	0.347	0.213	0.242
SEm (±)	0.016	0.049	0.018	0.028
CD (p=0.05)	0.0480	NS	0.0520	0.0820

Table 28. Magnesium and iron content as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23, %

Treatments	2021-22		2022-23	
	Mg	Fe	Mg	Fe
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.499	0.033	0.326	0.045
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.554	0.036	0.329	0.049
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.296	0.016	0.250	0.028
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.438	0.029	0.289	0.040
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.300	0.012	0.226	0.021
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.252	0.010	0.190	0.022
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.384	0.028	0.282	0.035
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.265	0.022	0.242	0.025
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.314	0.021	0.264	0.028
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.303	0.015	0.174	0.019
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.338	0.014	0.275	0.031
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.248	0.011	0.154	0.020
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.171	0.006	0.114	0.014
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.269	0.019	0.212	0.024
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.265	0.013	0.199	0.026
SEm (±)	0.028	0.001	0.014	0.002
CD (p=0.05)	0.0810	0.0040	0.0410	0.0050

Table 29. Zinc content as influenced by nutrient levels during *Rabi* 2021-22 and 2022-23,  
(%)

Treatments	2021-22	2022-23
	Zn	Zn
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	0.025	0.026
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.023	0.026
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.018	0.025
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.022	0.026
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.015	0.025
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.016	0.020
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.021	0.024
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.017	0.025
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.019	0.023
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.014	0.021
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.020	0.023
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.013	0.019
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.010	0.019
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.014	0.023
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.015	0.022
SEm (±)	0.001	0.002
CD (p=0.05)	0.0030	NS

During both years, T<sub>13</sub> resulted in the lowest P uptake by seed, haulm and total uptake.

#### **4.1.6.3 K Uptake**

Potassium uptake varied significantly with nutrient levels (Tables 34 and 35). During 2021-22, K uptake by seed, haulm and total uptake were higher in T<sub>1</sub> (13.6 kg ha<sup>-1</sup>, 30.8 kg ha<sup>-1</sup> and 44.4 kg ha<sup>-1</sup>, respectively) which was on par with T<sub>2</sub> (13.2 kg ha<sup>-1</sup>, 29.4 kg ha<sup>-1</sup> and 43.6 kg ha<sup>-1</sup>, respectively). During 2022-23, the K uptake by seed and total K uptake were significantly higher in T<sub>1</sub> (14.2 kg ha<sup>-1</sup> and 49.7 kg ha<sup>-1</sup>, respectively). While K uptake by haulm was higher in T<sub>1</sub> (35.5 kg ha<sup>-1</sup>) which was on par with T<sub>2</sub> (34.1 kg ha<sup>-1</sup>). Similar to that of N and P uptake, the lowest K uptake was observed in T<sub>13</sub> during both years.

#### **4.1.6 Soil Analysis**

The results on the effect of nutrient levels on post experiment status of soil organic carbon, available N, P and K during 2021-22 and 2022-23 are presented in Tables 36 and 37.

##### **4.1.5.1 Soil Organic Carbon**

Soil organic carbon content (SOC) varied significantly with nutrient levels. Among the nutrient levels, higher organic carbon was observed in T<sub>1</sub> (1.05%) which was on par with T<sub>2</sub> (1.00%) during 2021-22. While during 2022-23, the highest SOC content was observed in T<sub>1</sub> (1.11%). During both the years, T<sub>13</sub> had the lowest soil organic carbon.

##### **4.1.5.2 Available Nitrogen**

Perusal of data on available N in the post experiment soil revealed that T<sub>1</sub> (241.4 kg ha<sup>-1</sup>) recorded higher available N in the post experiment soil and it was on par with T<sub>2</sub> (238.4 kg ha<sup>-1</sup>) and T<sub>4</sub> (235.7 kg ha<sup>-1</sup>) during 2021-22. While, during 2022-23, the highest available N was observed in T<sub>1</sub> (200.6 kg ha<sup>-1</sup>) and it was followed by T<sub>2</sub>. During both years, the lowest available N was noted in T<sub>13</sub>.

##### **4.1.5.3 Available Phosphorus**

Available P in the post experiment soil was significantly influenced by nutrient levels. During both years, T<sub>1</sub> had significantly higher available P in the soil

(33.1 kg ha<sup>-1</sup> and 33.9 kg ha<sup>-1</sup>) which was on par with T<sub>2</sub> (31.8 kg ha<sup>-1</sup> and 33.0 kg ha<sup>-1</sup>, respectively). The lowest available P content in soil was observed in T<sub>13</sub> during 2021-22 and T<sub>12</sub> during 2022-23.

#### **4.1.5.4 Available Potassium**

Available K in the soil differed significantly with nutrient levels. The treatment T<sub>1</sub> resulted in significantly higher K status in post experiment soil, during 2021-22 (212.9 kg ha<sup>-1</sup>) and it was followed by T<sub>2</sub>. However, during 2022-23, T<sub>2</sub> (179.7 kg ha<sup>-1</sup>) resulted in higher available K in the soil which was on par with T<sub>1</sub> (176.6 kg ha<sup>-1</sup>). During both years, the lowest available K content in the soil was observed in T<sub>13</sub>.

#### **4.1.7 Economics**

Economics of cultivation were worked out in terms of gross return, net return and B:C ratio and are presented in Tables 38, 39 and 40.

##### **4.1.7.1 Gross Return**

Among the treatments, T<sub>1</sub> had the highest gross return during 2021-22 and 2022-23 (₹ 65452 ha<sup>-1</sup> and ₹ 72114 ha<sup>-1</sup>, respectively) T<sub>1</sub>, which was followed by T<sub>2</sub>. The pooled analysis of gross return during both years revealed that the highest gross return was observed in T<sub>1</sub> (₹ 68783 ha<sup>-1</sup>).

##### **4.1.7.2 Net Return**

Similar to gross return, the highest net return during both years (₹ 34482 ha<sup>-1</sup> and ₹ 41144 ha<sup>-1</sup>, respectively) were observed in T<sub>1</sub>. The pooled analysis of net return during both years revealed that the highest net return was observed in T<sub>1</sub> (₹ 37813 ha<sup>-1</sup>).

##### **4.1.7.3 Benefit Cost Ratio**

The highest B:C ratio during 2021-22 (2.1) and 2022-23 (2.3) were also noted in T<sub>1</sub> and was followed by T<sub>2</sub>. The lowest gross return, net return and B:C ratio were observed in T<sub>13</sub> during both years. The pooled analysis of B:C ratio during both years revealed that the highest B:C ratio was observed in T<sub>1</sub> (2.2).

Table 30. Nitrogen uptake as influenced by nutrient levels during *Rabi* 2021-22, kg ha<sup>-1</sup>

Treatments	2021-22		
	Seed uptake	Haulm uptake	Total uptake
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	33.0	37.0	70.0
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	32.0	35.7	67.7
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	24.2	30.1	54.3
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	30.4	34.2	64.6
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	23.6	26.9	50.5
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	20.9	24.6	45.5
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	29.2	34.0	63.2
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	24.1	28.8	52.9
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	26.4	31.3	57.7
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	19.4	23.6	43.0
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	27.8	32.4	60.2
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	18.1	22.5	40.6
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	16.7	21.0	37.7
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	22.5	26.5	49.0
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	21.4	25.4	46.8
SEm (±)	0.6	0.9	1.3
CD (p=0.05)	1.73	2.50	3.89

Table 31. Nitrogen uptake as influenced by nutrient levels during *Rabi* 2022-23, kg ha<sup>-1</sup>

Treatments	2022-23		
	Seed uptake	Haulm uptake	Total uptake
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	37.2	41.8	79.0
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	35.7	40.1	75.8
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	30.0	33.1	63.1
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	33.5	37.6	71.1
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	25.1	31.3	56.4
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	20.9	26.4	47.3
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	32.4	36.1	68.5
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	26.5	32.1	58.6
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	29.4	33.8	63.2
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	19.5	24.9	44.4
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	30.7	34.9	65.6
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	18.3	23.1	41.4
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	17.2	21.2	38.4
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	24.3	28.8	53.1
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	22.6	27.7	50.3
SEm (±)	0.6	0.6	1.0
CD (p=0.05)	1.78	1.64	2.97

Table 32. Phosphorus uptake as influenced by nutrient levels during *Rabi* 2021-22, kg ha<sup>-1</sup>

Treatments	2021-22		
	Seed uptake	Haulm uptake	Total uptake
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	3.6	8.6	12.2
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	3.5	7.8	11.3
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	2.5	6.7	9.2
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	3.2	7.6	10.8
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	2.1	6.2	8.3
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	1.7	5.8	7.5
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	3.3	7.6	10.9
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	2.2	6.4	8.6
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	2.7	6.9	9.6
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	1.6	5.2	6.8
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	3.1	7.5	10.6
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	1.4	4.9	6.3
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	1.2	4.7	5.9
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	1.9	6.0	7.9
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	1.8	5.9	7.7
SEm (±)	0.1	0.2	0.2
CD (p=0.05)	0.27	0.60	0.53

Table 33. Phosphorus uptake as influenced by nutrient levels during *Rabi* 2022-23, kg ha<sup>-1</sup>

Treatments	2022-23		
	Seed uptake	Haulm uptake	Total uptake
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	4.6	10.3	14.9
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	4.0	9.7	13.7
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	2.6	7.5	10.1
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	3.8	9.6	13.4
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	2.2	6.8	9.0
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	1.8	5.8	7.6
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	3.5	8.9	12.3
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	2.3	7.1	9.4
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	2.9	7.8	10.8
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	1.6	5.7	7.3
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	3.2	8.3	11.6
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	1.4	5.4	6.8
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	1.3	4.9	6.2
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	2.0	6.5	8.5
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	1.9	6.1	8.0
SEm (±)	0.1	0.2	0.3
CD (p=0.05)	0.28	0.70	0.78

Table 34. Potassium uptake as influenced by nutrient levels during *Rabi* 2021-22, kg ha<sup>-1</sup>

Treatments	2021-22		
	Seed uptake	Haulm uptake	Total uptake
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	13.6	30.8	44.4
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	13.2	29.4	43.6
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	11.1	27.6	38.7
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	12.9	28.7	41.6
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	10.9	27.0	37.9
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	9.7	25.4	35.1
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	12.5	28.5	41.0
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	10.7	27.7	38.4
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	11.8	27.8	39.6
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	8.9	24.9	33.9
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	12.2	28.3	40.5
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	8.4	24.0	32.4
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	7.9	21.4	29.3
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	10.4	26.3	36.7
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	10.1	25.6	35.7
SEm (±)	0.2	0.5	0.5
CD (p=0.05)	0.53	1.43	1.53

Table 35. Potassium uptake as influenced by nutrient levels during *Rabi* 2022-23, kg ha<sup>-1</sup>

Treatments	2022-23		
	Seed uptake	Haulm uptake	Total uptake
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	14.2	35.5	49.7
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	13.7	34.1	47.4
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	11.3	30.4	41.7
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	13.2	33.2	46.4
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	11.3	30.2	41.5
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	9.5	28.7	38.2
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	12.6	32.8	45.4
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	10.6	31.0	41.6
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	11.9	40.0	42.8
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	8.9	29.2	38.2
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	12.1	31.6	43.7
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	8.5	28.7	37.2
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	7.9	26.0	33.9
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	10.6	29.7	40.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	10.1	29.1	39.3
SEm (±)	0.1	0.6	0.6
CD (p=0.05)	0.40	1.84	1.83

Table 36. Organic carbon, Available N, P and K as influenced by nutrient levels during *Rabi* 2021-22

Treatments	2021-22			
	Organic carbon (%)	Available N (kg ha <sup>-1</sup> )	Available P (kg ha <sup>-1</sup> )	Available K (kg ha <sup>-1</sup> )
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	1.05	241.4	33.1	212.9
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	1.00	238.4	31.8	207.3
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.85	224.2	28.0	188.1
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.94	235.7	30.9	203.5
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.82	219.1	27.2	183.7
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.78	202.3	25.5	173.2
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.91	232.1	30.0	198.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.84	221.5	27.6	185.9
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.86	226.7	28.4	191.7
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.77	194.4	24.9	170.3
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.89	229.8	29.4	194.1
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.77	189.4	24.2	167.0
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.75	183.7	23.2	164.1
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.80	212.0	26.6	180.0
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.78	205.4	26.2	176.9
SEm (±)	0.02	2.1	0.6	1.9
CD (p=0.05)	0.048	6.08	1.58	5.44

Table 37. Organic carbon, Available N, P and K as influenced by nutrient levels during *Rabi* 2022-23

Treatments	2022-23			
	Organic carbon (%)	Available N (kg ha <sup>-1</sup> )	Available P (kg ha <sup>-1</sup> )	Available K (kg ha <sup>-1</sup> )
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	1.11	200.6	33.9	176.6
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	0.99	192.2	33.0	179.7
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	0.84	177.8	25.4	159.5
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	0.98	189.1	28.2	171.6
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	0.81	173.4	23.9	153.8
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	0.75	166.9	21.8	143.6
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	0.93	186.1	27.4	168.1
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	0.82	175.7	24.9	157.1
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	0.87	180.5	25.9	161.9
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	0.74	164.8	20.9	139.6
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	0.89	183.3	26.5	164.8
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	0.72	162.1	19.0	135.1
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	0.70	158.0	19.5	130.9
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	0.79	171.5	23.3	149.0
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	0.77	169.9	22.5	145.8
SEm (±)	0.02	0.8	0.6	1.4
CD (p=0.05)	0.049	2.39	1.72	4.13

Table 38. Economics of cultivation, as influenced by nutrient levels during *Rabi* 2021-22

Treatments	Gross return ₹ ha <sup>-1</sup>	Net return ₹ ha <sup>-1</sup>	B:C ratio
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	65452	34482	2.1
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	56529	25295	1.8
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	43034	11614	1.4
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	54072	22388	1.7
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	41484	10208	1.3
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	37732	6192	1.2
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	52711	20985	1.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	42912	10922	1.3
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	45568	14308	1.5
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	37402	5702	1.2
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	51807	20698	1.7
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	36541	4681	1.1
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	32367	1138	1.0
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	40203	8464	1.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	38084	6600	1.2
SEm (±)	856	856	0.1
CD (p=0.05)	2479.7	2479.7	0.08

Table 39. Economics of cultivation, as influenced by nutrient levels during *Rabi* 2022-23

Treatments	Gross return ₹ ha <sup>-1</sup>	Net return ₹ ha <sup>-1</sup>	B:C ratio
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	72114	41144	2.3
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	62870	31636	2.0
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	49348	17928	1.5
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	60430	28746	1.9
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	45760	14484	1.4
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	42465	10925	1.3
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	55617	23891	1.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	48566	16576	1.5
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	50331	19071	1.6
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	43654	11954	1.3
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	53655	22546	1.7
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	43822	11963	1.3
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	37419	6190	1.1
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	43063	11323	1.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	44941	13457	1.4
SEm (±)	1899	1899	0.1
CD (p=0.05)	5499.8	5499.8	0.17

Table 40. Pooled analysis of economics of cultivation during *Rabi* 2021-22 and *Rabi* 2022-23

Treatments	Pooled analysis		
	Gross return ₹ ha <sup>-1</sup>	Net return ₹ ha <sup>-1</sup>	B:C ratio
T <sub>1</sub> : 31:20:16 kg NPK ha <sup>-1</sup>	68783	37813	2.2
T <sub>2</sub> : 64:20:16 kg NPK ha <sup>-1</sup>	59699	28465	1.9
T <sub>3</sub> : 31:50:16 kg NPK ha <sup>-1</sup>	46191	14771	1.5
T <sub>4</sub> : 64:50:16 kg NPK ha <sup>-1</sup>	57251	25567	1.8
T <sub>5</sub> : 31:20:34 kg NPK ha <sup>-1</sup>	43622	12346	1.4
T <sub>6</sub> : 64:20:34 kg NPK ha <sup>-1</sup>	40099	8559	1.3
T <sub>7</sub> : 31:50:34 kg NPK ha <sup>-1</sup>	54164	22438	1.7
T <sub>8</sub> : 64:50:34 kg NPK ha <sup>-1</sup>	45739	13749	1.4
T <sub>9</sub> : 20:35:25 kg NPK ha <sup>-1</sup>	47949	16689	1.5
T <sub>10</sub> : 75:35:25 kg NPK ha <sup>-1</sup>	40528	8828	1.3
T <sub>11</sub> : 48:10:25 kg NPK ha <sup>-1</sup>	52730	21622	1.7
T <sub>12</sub> : 48:60:25 kg NPK ha <sup>-1</sup>	40181	8322	1.2
T <sub>13</sub> : 48:35:10 kg NPK ha <sup>-1</sup>	34893	3664	1.1
T <sub>14</sub> : 48:35:40 kg NPK ha <sup>-1</sup>	41633	9894	1.3
T <sub>15</sub> : 48:35:25 kg NPK ha <sup>-1</sup>	41512	10029	1.3
SEm (±)	1008	1008	0.1
CD (p=0.05)	2920.8	2920.8	0.20

## 4.2 EXPERIMENT II: ASSESSMENT OF THE RESPONSE OF PROMISING SESAME VARIETIES TO THE IDENTIFIED OPTIMUM NUTRIENT LEVELS

### 4.2.1 Growth Characters

#### 4.2.1.1 Plant Height

The effect of different nutrient levels and varieties on plant height of sesame at different growth stages are presented in Tables 41 and 42.

Significant variations in the plant height of sesame were observed with the application of nutrients at different levels. At 20 DAS, 40 DAS and 60 DAS, taller plants were observed in  $n_2$  (14.2 cm, 99.3 cm, 158.0, respectively) which was on par with  $n_3$  at 20 DAS (13.9 cm). However, it was on par with  $n_3$  and  $n_4$ , at 40 DAS (99.1 cm and 95.6 cm, respectively) and 60 DAS, (157.4 cm and 154.3 cm, respectively). At harvest  $n_2$  was significantly superior over other treatments (176.8 cm). At all stages of observation, the shortest plants were observed in  $n_5$ .

Significant variations in plant height were observed among varieties. Among the varieties, the tallest plants were observed in  $v_5$  (GT 10) at 20 DAS, 40 DAS and at harvest (15.3 cm, 109.4 cm and 177.1 cm, respectively). However, at 60 DAS,  $v_5$  (162.5 cm) was on par with  $v_4$  (Thilak) (159.9 cm). At all stages of observation, Thilarani ( $v_3$ ) resulted in the shortest plants (11.8 cm, 91.1 cm, 140.9 cm and 154.5 cm, respectively).

Interaction effect of nutrient levels over varieties was found significant. At 20 DAS, 60 DAS and harvest, taller plants were produced by  $n_2v_5$  (16.9 cm, 175.7 cm and 192.7 cm, respectively). However, at 20 DAS it was on par with  $n_3v_5$  and  $n_3v_4$  (16.7 cm and 15.5 cm, respectively). At 40 DAS, taller plants were observed in  $n_3v_5$  (116.0 cm) which was on par with  $n_1v_4$ ,  $n_2v_5$  and  $n_4v_5$  (112.7 cm, 111.0 cm and 107.7 cm, respectively). Whereas, at 60 DAS and at harvest,  $n_2v_5$  was on par with  $n_2v_4$  (171.7 cm and 189.0 cm, respectively).

The interaction effect of varieties over nutrient levels were also found significant at all stages of growth. Kayamkulam 1 ( $v_1$ ) (14.3 cm), Thilathara ( $v_2$ ) (14.6 cm), Thilarani ( $v_3$ ) (12.6 cm) and GT 10 ( $v_5$ ) (16.9 cm) produced taller plants

at nutrient level  $n_2$  at 20 DAS. However, Thilak ( $v_4$ ) (15.5 cm) and TMV 7 ( $v_6$ ) (14.2 cm) produced taller plants at nutrient level  $n_3$  and  $n_4$ , respectively. At 40 DAS,  $v_1$ ,  $v_2$  and  $v_6$  produced taller plants at  $n_2$  (106.3 cm, 101.7 cm and 99.8 cm, respectively). However,  $v_3$ ,  $v_4$  and  $v_5$  produced taller plants at  $n_4$  (98.3 cm),  $n_1$  (112.7 cm) and  $n_3$  (116.0 cm), respectively. At 60 DAS,  $v_2$ ,  $v_4$ ,  $v_5$  and  $v_6$  produced taller plants at  $n_2$  (157.0 cm, 171.7 cm, 175.7 cm and 154.3 cm, respectively). However,  $v_1$  and  $v_3$  produced taller plants at  $n_3$  (160.0 cm and 156.0 cm, respectively). At harvest, all the varieties produced taller plants at  $n_2$  except  $v_3$  which produced taller plants at  $n_3$ .

#### ***4.2.1.2 Number of Leaves per Plant***

Tables 43 and 44 depicted the variations in number of leaves per plant due to the individual and interaction effects of nutrient levels and varieties.

The nutrient levels had no significant effect on number of leaves per plant at 20 DAS. At 40 DAS, the greatest number of leaves per plant were observed in  $n_2$  (38.3). However, at 60 DAS, greater number of leaves per plant were observed in  $n_2$  (72.6) which was on par with  $n_3$  (70.0).

The number of leaves per plant varied among the sesame varieties. At 20 DAS, no significant effect was observed. However, at 40 DAS, GT 10 ( $v_5$ ) resulted in the greatest number of leaves per plant (41.1). While, at 60 DAS,  $v_5$  (68.7) recorded greater number of leaves per plant and was on par with Thilak ( $v_4$ ) (65.3). At 40 DAS and 60 DAS,  $v_3$  (Thilarani) resulted in the lowest number of leaves per plant.

Interaction effect of nutrients over varieties was found significant only at 40 DAS and 60 DAS. At 40 DAS,  $n_2v_5$  recorded greater number of leaves per plant (49.6) and was on par with  $n_2v_4$  (43.0) and  $n_3v_5$  (40.7). However, at 60 DAS,  $n_2v_5$  recorded greater number of leaves per plant (81.7) which was on par with  $n_3v_5$  (79.7),  $n_2v_4$  (77.7),  $n_3v_3$  (77.0) and  $n_2v_1$  (73.0).

Similarly, the effect of varieties over nutrient levels were also significant at 40 DAS and 60 DAS. At 40 DAS, all varieties produced greater number of leaves

per plant at nutrient level  $n_2$ . While, at 60 DAS, all varieties except Thilarani produced greater number of leaves per plant at nutrient level  $n_2$ . Thilarani produced greater number of leaves per plant at nutrient level  $n_3$ . At both 40 DAS and 60 DAS, all the varieties produced the lowest number of leaves at nutrient level  $n_5$ .

#### ***4.2.1.3 Number of Branches per Plant***

Perusal of the data revealed that number of branches per plant was significantly influenced by nutrient levels and varieties at 40 DAS and 60 DAS.

At 40 DAS and 60 DAS, greater number of branches per plant were observed in  $n_2$  (4.3 and 5.2, respectively) which was on par with  $n_3$  (4.0 and 4.9, respectively). While, lower number of branches per plant was observed in  $n_5$  at both stages.

Among the varieties, GT 10 ( $v_5$ ) produced significantly greater number of branches per plant at 40 DAS and 60 DAS (5.7 and 6.3, respectively). The variety, Thilarani ( $v_3$ ) produced lower number of branches per plant at both stages (2.9 and 3.7, respectively).

The interaction effect of nutrient levels over varieties and varieties over nutrient levels were found non-significant.

#### ***4.2.1.4 Dry Matter Production***

Tables 47 and 48 revealed the influence of nutrient levels, varieties and their interaction on DMP at 20 DAS, 40 DAS, 60 DAS and harvest.

The nutrient levels influenced the DMP at 40 DAS, 60 DAS and harvest only. At 40 DAS, 60 DAS and harvest, the highest DMP was observed in  $n_2$  (10.42 g per plant, 16.91 g per plant and 19.84 g per plant, respectively).

Varieties significantly influenced the DMP at all stages. Among the different varieties, at 20 DAS, Thilak ( $v_4$ ) resulted in higher DMP (0.55 g per plant) which was on par with GT 10 ( $v_5$ ) (0.54 g per plant). At 40 DAS,  $v_5$  produced higher DMP (10.79 g per plant) which was on par with  $v_4$  (10.44 g per plant). At 60 DAS

and harvest, the highest DMP were observed in v<sub>5</sub> (16.46 g per plant and 19.71 g per plant, respectively).

The interaction effect of nutrient levels over varieties were significant only at 60 DAS and harvest. At 60 DAS, higher DMP was noted in n<sub>2</sub>v<sub>5</sub> (18.63 g per plant) which was on par with n<sub>2</sub>v<sub>4</sub> (18.02 g per plant). However, at harvest, the highest DMP was observed in n<sub>2</sub>v<sub>5</sub> (21.70 g per plant).

Similarly, the interaction effect of varieties over nutrient levels were significant only at 60 DAS and harvest. All varieties produced higher DMP at nutrient level n<sub>2</sub> which was followed by n<sub>1</sub> at both 60 DAS and harvest.

## **4.2.2 Physiological Parameters**

### **4.2.2.1 Leaf Area Index (LAI)**

Tables 49 and 50 depicts the variations in LAI due to the individual and interaction effects of nutrient levels and varieties.

At 40 DAS and 60 DAS, higher LAI were observed in n<sub>2</sub> (2.54 and 5.89, respectively) which was on par with n<sub>1</sub> (2.30 and 5.44, respectively). The lowest LAI was noted in n<sub>5</sub> at 40 DAS and 60 DAS (1.41 and 3.43, respectively).

Among the different varieties, the highest LAI was recorded by GT 10 (v<sub>5</sub>) at 40 DAS (2.98). While at 60 DAS, v<sub>5</sub> recorded higher LAI (5.61) and it was on par with Thilak (v<sub>4</sub>) (5.07). The lowest LAI was noted in Thilarani at both 40 DAS and 60 DAS (1.29 and 4.16, respectively).

The interaction effect of nutrient levels over varieties had significant effect on LAI at 40 DAS and 60 DAS. At 40 DAS, the interaction n<sub>2</sub>v<sub>5</sub> recorded higher LAI (4.36) which was on par with n<sub>2</sub>v<sub>4</sub> (3.83) and n<sub>1</sub>v<sub>5</sub> (3.50). At 60 DAS, the highest LAI was observed in n<sub>2</sub>v<sub>5</sub> (8.59). The treatments n<sub>5</sub>v<sub>2</sub> and n<sub>5</sub>v<sub>3</sub> resulted in the lowest LAI at 40 DAS and 60 DAS, respectively.

Table 41. Effect of nutrient levels and varieties on plant height at 20 DAS and 40 DAS during *Rabi* 2023-24, cm

Nutrient levels (N)	Plant height																	
	20 DAS							40 DAS										
	Varieties (V)																	
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean				
n <sub>1</sub>	12.5	13.5	10.8	12.6	14.9	13.2	13.2	102.3	98.7	94.3	112.7	105.7	70.7	91.9				
n <sub>2</sub>	14.3	14.6	12.6	15.2	16.9	13.8	14.2	106.3	101.7	89.7	106.7	111.0	99.8	99.3				
n <sub>3</sub>	13.8	14.2	11.1	15.5	16.7	12.1	13.9	93.3	89.7	84.0	93.0	116.0	85.7	99.1				
n <sub>4</sub>	12.4	12.2	12.0	14.5	14.7	14.2	13.4	104.0	98.3	98.3	101.7	107.7	89.0	95.6				
n <sub>5</sub>	13.0	10.8	10.3	11.5	13.3	12.8	12.0	91.0	90.0	89.0	101.0	99.7	93.0	90.7				
Mean	13.2	13.1	11.8	14.1	15.3	12.7		99.4	95.7	91.1	103.0	109.4	87.6					
	SEm (±)						CD (0.05)						SEm (±)		CD (0.05)			
n	0.2						0.49						n		1.3		4.08	
v	0.2						0.67						v		1.5		4.13	
n×v	0.5						1.49						n×v		3.3		9.23	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.5						1.45						n(v <sub>i</sub> ×v <sub>j</sub> )		3.2		9.35	

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 42. Effect of nutrient levels and varieties on plant height at 60 DAS and harvest during *Rabi* 2023-24, cm

Nutrient levels (N)	Plant height															
	60 DAS							Harvest								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	132.3	134.3	132.0	150.3	156.7	145.0	142.1	153.0	144.3	161.0	161.0	175.7	154.3	156.2		
n <sub>2</sub>	149.3	157.0	140.0	171.7	175.7	154.3	158.0	170.7	174.0	164.7	189.0	192.7	170.0	176.8		
n <sub>3</sub>	160.0	154.0	156.0	162.7	166.0	146.3	157.4	168.3	166.0	165.3	171.0	179.3	157.7	167.9		
n <sub>4</sub>	158.3	151.7	152.0	159.0	159.3	145.7	154.3	165.7	161.0	163.0	165.3	172.7	154.3	163.7		
n <sub>5</sub>	138.7	140.7	124.3	145.7	153.3	145.0	141.3	145.3	149.7	135.3	159.3	165.3	152.7	151.3		
Mean	147.7	147.5	140.9	159.9	162.5	147.7		160.6	159.9	154.5	169.1	177.1	157.8			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	1.5						4.98		0.8						2.73	
v	1.5						4.12		1.5						4.25	
n×v	3.2						9.21		3.3						9.49	
n(v <sub>i</sub> ×v <sub>j</sub> )	3.3						9.75		3.2						9.08	

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 43. Effect of nutrient levels and varieties on number of leaves per plant at 20 DAS and 40 DAS during *Rabi* 2023-24

Nutrient levels (N)	Number of leaves per plant															
	20 DAS							40 DAS								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	6.0	6.0	6.0	6.0	6.0	6.0	6.0	32.0	31.7	25.3	32.7	38.7	29.3	31.6		
n <sub>2</sub>	6.0	6.0	6.0	6.0	6.0	6.0	6.0	33.7	33.7	32.3	43.0	49.6	37.3	38.3		
n <sub>3</sub>	6.0	6.0	6.0	6.0	6.0	6.0	6.0	31.0	31.0	28.0	32.0	40.7	35.0	32.9		
n <sub>4</sub>	6.0	6.0	6.0	6.0	6.0	6.0	6.0	28.0	29.3	23.3	29.7	39.3	27.0	29.4		
n <sub>5</sub>	6.6	6.0	6.0	6.0	6.0	6.0	6.0	27.0	24.3	22.7	29.3	37.0	26.3	27.8		
Mean	6.0	6.0	6.0	6.0	6.0	6.0		30.3	30.0	26.3	34.3	41.1	31.4			
	SEm (±)						CD (0.05)						SEm (±)		CD (0.05)	
n	0						NS						n		0.8	
v	0						NS						v		1.5	
n×v	0						NS						n×v		3.3	
n(v <sub>i</sub> ×v <sub>j</sub> )	0						NS						n(v <sub>i</sub> ×v <sub>j</sub> )		3.2	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

- n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>
- n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>
- n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>
- n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>
- n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

- v<sub>1</sub>- Kayamkulam 1
- v<sub>2</sub>- Thilathara
- v<sub>3</sub> - Thilarani
- v<sub>4</sub> - Thilak
- v<sub>5</sub> - GT 10
- v<sub>6</sub> -TMV 7

Table 44. Effect of nutrient levels and varieties on number of leaves per plant at 60 DAS, during *Rabi* 2023-24

Nutrient levels (N)	Number of leaves per plant						
	60 DAS						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	58.7	56.7	52.3	61.3	62.7	56.0	57.9
n <sub>2</sub>	73.0	70.7	62.3	77.7	81.7	70.3	72.6
n <sub>3</sub>	57.0	66.0	77.0	68.7	79.7	63.0	70.0
n <sub>4</sub>	64.3	63.7	52.3	60.0	62.0	58.3	60.1
n <sub>5</sub>	55.0	51.7	46.7	58.7	57.3	51.3	53.4
Mean	62.6	61.7	58.2	65.3	68.7	59.7	
	SEm (±)		CD (0.05)				
n	0.8		2.67				
v	1.5		4.29				
n×v	3.4		9.58				
n(v <sub>i</sub> ×v <sub>j</sub> )	3.2		9.14				

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 45. Effect of nutrient levels and varieties on number of branches per plant at 20 DAS and 40 DAS during *Rabi* 2023-24

Nutrient levels (N)	Number of branches per plant															
	20 DAS							40 DAS								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.2	4.3	2.3	2.3	5.7	4.7	3.8		
n <sub>2</sub>	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.3	4.0	3.7	5.0	6.7	3.3	4.3		
n <sub>3</sub>	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	4.7	2.7	4.7	6.0	4.3	4.0		
n <sub>4</sub>	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.6	2.7	3.7	3.3	5.3	3.0	3.5		
n <sub>5</sub>	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.3	3.3	2.0	3.0	4.7	2.7	3.1		
Mean	1.0	1.0	1.0	1.0	1.0	1.0		3.1	3.8	2.9	3.7	5.7	3.6			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0						NS		n						0.1	
v	0						NS		v						0.3	
n×v	0						NS		n×v						0.6	
n(v <sub>i</sub> ×v <sub>j</sub> )	0						NS		n(v <sub>i</sub> ×v <sub>j</sub> )						0.6	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 46. Effect of nutrient levels and varieties on number of branches per plant at 60 DAS during *Rabi* 2023-24

Nutrient levels (N)	Number of branches per plant						
	60 DAS						
	Varieties (V)						
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	5.3	5.1	3.7	4.1	6.0	5.0	4.8
n <sub>2</sub>	4.7	5.0	4.0	5.7	7.7	4.0	5.2
n <sub>3</sub>	4.3	5.0	3.3	5.0	6.7	4.7	4.9
n <sub>4</sub>	3.3	3.7	4.3	4.3	5.7	4.3	4.2
n <sub>5</sub>	4.3	3.3	3.0	4.0	5.3	3.7	4.1
Mean	4.3	4.5	3.7	5.0	6.3	4.0	
	SEm (±)		CD (0.05)				
n	0.1		0.31				
v	0.2		0.67				
n×v	0.5		NS				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.5		NS				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 47. Effect of nutrient levels and varieties on dry matter production at 20 DAS and 40 DAS during *Rabi* 2023-24, g per plant

Nutrient levels (N)	Dry matter production															
	20 DAS							40 DAS								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	0.48	0.52	0.47	0.54	0.53	0.47	0.50	10.10	9.67	8.10	10.77	11.67	9.40	9.95		
n <sub>2</sub>	0.53	0.49	0.52	0.59	0.58	0.50	0.54	10.83	9.80	8.47	11.70	12.63	9.07	10.42		
n <sub>3</sub>	0.53	0.50	0.50	0.56	0.57	0.54	0.53	8.53	7.90	6.77	8.67	9.63	7.33	8.14		
n <sub>4</sub>	0.53	0.52	0.51	0.54	0.51	0.47	0.52	8.77	7.93	6.53	9.83	10.90	7.33	8.55		
n <sub>5</sub>	0.47	0.49	0.47	0.53	0.52	0.50	0.49	8.53	7.53	5.98	8.87	9.13	6.10	7.69		
Mean	0.51	0.51	0.49	0.55	0.54	0.49		9.35	8.57	7.17	10.44	10.79	7.85			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.01						NS		0.09						0.318	
v	0.01						0.032		0.13						0.374	
n×v	0.03						NS		0.30						NS	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.02						NS		0.30						NS	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 48. Effect of nutrient levels and varieties on dry matter production at 60 DAS and harvest during *Rabi* 2023-24, g per plant

Nutrient levels (N)	Dry matter production															
	60 DAS							Harvest								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	15.70	14.77	12.90	16.73	17.97	13.63	15.23	18.67	17.57	15.90	19.57	20.88	16.47	18.12		
n <sub>2</sub>	17.17	16.90	14.73	18.02	18.63	16.47	16.91	20.07	19.60	17.47	20.43	21.70	18.80	19.84		
n <sub>3</sub>	12.27	11.57	9.67	13.67	15.23	10.67	12.18	17.40	17.03	14.43	18.47	19.33	15.80	17.08		
n <sub>4</sub>	14.80	13.90	11.33	14.90	16.63	12.90	14.07	16.90	16.07	14.57	17.57	18.47	15.07	16.44		
n <sub>5</sub>	11.80	10.30	8.23	13.27	14.13	9.07	11.13	15.30	14.37	11.60	16.43	17.47	13.33	14.75		
Mean	14.35	13.49	11.37	15.22	16.46	12.55		17.67	16.93	14.79	18.49	19.71	15.89			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.11						0.363		0.18						0.603	
v	0.10						0.289		0.11						0.304	
n×v	0.23						0.647		0.24						0.680	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.24						0.692		0.29						0.863	

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

The interaction effect of varieties over nutrient levels revealed that at 40 DAS, Kayamkulam 1 ( $v_1$ ) (2.11), Thilarani ( $v_3$ ) (1.95), Thilak ( $v_4$ ) (3.83) and GT 10 ( $v_5$ ) (4.36) recorded higher LAI at nutrient level  $n_2$ . While, Thilathara ( $v_2$ ) and TMV 7( $v_6$ ) recorded higher LAI at nutrient level  $n_1$ . However, at 60 DAS, all varieties recorded higher LAI at nutrient level  $n_2$ .

#### **4.2.2.2 Chlorophyll Content**

The response of nutrient levels and varieties on chlorophyll content at 20 DAS, 40 DAS and 60 DAS are given in Tables 51 and 52.

At 20 DAS, the nutrient levels had no significant effect on the chlorophyll content of leaves. At 40 DAS, nutrient level  $n_2$  resulted in the highest chlorophyll content (1.53 mg  $g^{-1}$  fresh weight). However, at 60 DAS, higher chlorophyll content was observed in  $n_2$  (2.35 mg  $g^{-1}$  fresh weight) and was on par with  $n_1$  (2.32 mg  $g^{-1}$  fresh weight).

Chlorophyll content was significantly influenced by varieties. At 20 DAS, the highest chlorophyll content was observed in GT 10 ( $v_5$ ) (0.64 mg  $g^{-1}$  fresh weight). At 40 DAS, higher chlorophyll content was noted in  $v_5$  (1.50 mg  $g^{-1}$  fresh weight) and was on par with Thilak ( $v_4$ ) (1.47 mg  $g^{-1}$  fresh weight). However, at 60 DAS, the highest chlorophyll content was observed in  $v_5$  (2.40 mg  $g^{-1}$  fresh weight).

The interaction effect of nutrient levels over varieties was significant only at 40 DAS and 60 DAS. At 40 DAS and 60 DAS, higher chlorophyll content was observed in  $n_2v_5$  (1.61 and 2.47 mg  $g^{-1}$  fresh weight, respectively). However, at 40 DAS, it was on par with  $n_2v_4$  (1.59 mg  $g^{-1}$  fresh weight),  $n_1v_5$  (1.56 mg  $g^{-1}$  fresh weight) and  $n_2v_1$  (1.55 mg  $g^{-1}$  fresh weight). While at 60 DAS,  $n_2v_5$  was on par with  $n_1v_5$  (2.44 mg  $g^{-1}$  fresh weight),  $n_2v_4$  (2.40 mg  $g^{-1}$  fresh weight) and  $n_4v_5$  (2.39 mg  $g^{-1}$  fresh weight).

Similarly, interaction effect of varieties over nutrient levels had significant effect on the chlorophyll content of leaves at 40 DAS and 60 DAS only. At 40 DAS and 60 DAS, all the varieties recorded higher chlorophyll content at nutrient level

n<sub>2</sub>. While all the varieties recorded the lowest chlorophyll content at nutrient level n<sub>5</sub>.

#### **4.2.2.3 Crop Growth Rate (CGR)**

Significant influence of nutrient levels and varieties on CGR at 20 DAS-40 DAS, 40 DAS-60 DAS and 60 DAS-harvest are presented in Tables 53 and 54.

Among the nutrient levels, n<sub>2</sub> resulted in the highest CGR at 20 DAS-40 DAS, 40 DAS-60 DAS and 60 DAS-harvest (0.494 g m<sup>-2</sup> d<sup>-1</sup>, 0.324 g m<sup>-2</sup> d<sup>-1</sup> and 0.243 g m<sup>-2</sup> d<sup>-1</sup>, respectively). While the lowest CGR at all growth stages were observed in n<sub>5</sub>.

The varieties also had significant effect on CGR at time intervals, 20 DAS-40 DAS and 40 DAS-60 DAS. Among the varieties, GT 10 (v<sub>5</sub>) recorded the highest CGR at 20 DAS-40 DAS (0.513 g m<sup>-2</sup> d<sup>-1</sup>). While at 40 DAS-60 DAS, higher CGR was observed in v<sub>5</sub> (0.283 g m<sup>-2</sup> d<sup>-1</sup>) which was on par with Thilak (v<sub>4</sub>) (0.263 g m<sup>-2</sup> d<sup>-1</sup>).

The interaction effect of nutrient levels over varieties revealed that the highest CGR at 20 DAS-40 DAS was observed in n<sub>2</sub>v<sub>5</sub> (0.603 g m<sup>-2</sup> d<sup>-1</sup>). However, higher CGR at 40 DAS-60 DAS and at 60 DAS-harvest were observed in n<sub>2</sub>v<sub>5</sub> (0.370 g m<sup>-2</sup> d<sup>-1</sup> and 0.273 g m<sup>-2</sup> d<sup>-1</sup>, respectively). At 40 DAS-60 DAS, n<sub>2</sub>v<sub>5</sub> was on par with n<sub>2</sub>v<sub>4</sub> (0.355 g m<sup>-2</sup> d<sup>-1</sup>) and at 60 DAS-harvest it was on par with n<sub>2</sub>v<sub>4</sub> (0.257 g m<sup>-2</sup> d<sup>-1</sup>) and n<sub>2</sub>v<sub>1</sub> (0.245 g m<sup>-2</sup> d<sup>-1</sup>).

The interaction effect of varieties over nutrient levels showed that at 20 DAS-40 DAS, all the varieties except TMV 7 resulted in higher CGR at nutrient level n<sub>2</sub>. However, TMV 7 recorded higher CGR at nutrient level n<sub>1</sub>. While at 40 DAS-60 DAS and 60 DAS-harvest, all the varieties recorded higher CGR at nutrient level n<sub>2</sub>.

#### **4.2.2.4 Relative Growth Rate (RGR)**

Influence of nutrient levels and varieties on RGR and their interactions at time intervals 20 DAS-40 DAS, 40 DAS-60 DAS and at 60 DAS-harvest are presented in Tables 55 and 56.

At all three time intervals, nutrient level  $n_2$  resulted in the highest RGR (0.149 g g<sup>-1</sup> d<sup>-1</sup>, 0.025 g g<sup>-1</sup> d<sup>-1</sup> and 0.015 g g<sup>-1</sup> d<sup>-1</sup>, respectively) and it was followed by  $n_1$ .

Varieties had significant effect on RGR only at 20 DAS-40 DAS. Among the varieties, GT 10 ( $v_5$ ) recorded the highest RGR (0.149 g g<sup>-1</sup> d<sup>-1</sup>) and the lowest RGR was observed in  $v_3$ .

Interaction effect of nutrients over varieties were found significant only at 20 DAS-40 DAS and 40 DAS-60 DAS. At 20 DAS-40 DAS,  $n_2v_5$  resulted in the highest RGR (0.156 g g<sup>-1</sup> d<sup>-1</sup>). Similarly, at 40 DAS-60 DAS,  $n_2v_5$  resulted in higher RGR (0.030 g g<sup>-1</sup> d<sup>-1</sup>) which was on par with  $n_2v_4$  (0.029 g g<sup>-1</sup> d<sup>-1</sup>),  $n_2v_1$  (0.027 g g<sup>-1</sup> d<sup>-1</sup>) and  $n_1v_5$  (0.025 g g<sup>-1</sup> d<sup>-1</sup>).

The interaction effect of varieties over nutrient levels were found significant only at 20 DAS-40 DAS and 40 DAS-60 DAS. At 20 DAS-40 DAS, all varieties except TMV 7 ( $v_6$ ) recorded higher RGR at nutrient level  $n_2$ . However,  $v_6$  recorded higher RGR at nutrient level  $n_1$ . While at 40 DAS-60 DAS, all varieties except Thilarani ( $v_3$ ) recorded higher RGR at  $n_2$  and  $v_3$  recorded higher RGR at  $n_1$ .

### **4.2.3 Yield Components and Yield**

#### **4.2.3.1 Days to 50 Per cent Flowering**

Days to 50 per cent flowering was not significantly influenced by the nutrient levels, varieties and its interaction effects.

#### **4.2.3.2 Number of Capsules per Plant**

The impact of nutrient levels, varieties and its interaction effects on number of capsules per plant are given in Table 57.

Among the nutrients levels, the greatest number of capsules per plant were observed in  $n_2$  (85.2) which was followed by  $n_1$  (74.9). However,  $n_5$  resulted in the lowest number of capsules per plant (65.6).

Among the varieties, the greatest number of capsules were noted in GT 10 ( $v_5$ ) (84.0) which was followed by  $v_4$  (Thilak) (74.0). However, the lowest number of capsules per plant were observed in Thilarani ( $v_3$ ) (60.3).

The interaction effect of nutrient levels over varieties was found to be significant. Among the treatments,  $n_2v_5$  produced greater number of capsules per plant (100.7) which was on par with  $n_2v_4$  (100.2). The lowest number of capsules per plant were observed in  $n_5v_3$ .

The interaction effect of varieties over nutrient levels revealed that, all varieties *viz.*, Kayamkulam 1 ( $v_1$ ) (90.3), Thilathara ( $v_2$ ) (89.3), Thilarani ( $v_3$ ), (69.0), Thilak ( $v_4$ ) (100.2), GT 10 ( $v_5$ ) (100.7) and TMV 7 ( $v_6$ ) (75.7) produced the greatest number of capsules per plant at nutrient level  $n_2$ .

#### **4.2.3.3 Number of Seeds per Capsule**

Perusal of the data in Table 58 revealed that nutrient levels and varieties had significant effect on number of seeds per capsule.

The nutrient level  $n_2$  resulted in the greatest number of seeds per capsule (72.0) and it was followed by  $n_1$  (69.6). The lowest number of seeds per capsule were observed in  $n_5$  (55.0).

Among the varieties, GT 10 ( $v_5$ ) produced significantly greater number of seeds per capsule (65.1) which was followed by Thilak ( $v_4$ ) (60.1). However, Thilarani ( $v_3$ ) produced the lowest number of seeds per capsule (51.6).

The interaction effect of nutrient levels over varieties and vice versa were not significant.

#### **4.2.3.4 Hundred Seed Weight**

Varieties only had significant effect on hundred seed weight. Among the varieties, GT 10 ( $v_5$ ) recorded the greatest hundred seed weight (0.344 g) which was followed by Thilak ( $v_4$ ) (0.312 g). The lowest hundred seed weight was noted in Thilarani ( $v_3$ ) (0.254 g).

#### **4.2.3.5 Seed Yield per Plant**

The influence of nutrient levels, varieties and its interaction on seed yield per plant are presented in Table 59.

Among the nutrient levels,  $n_2$  produced the highest seed yield per plant (24.8 g) which was followed by  $n_1$  (23.6 g) and  $n_1$  was statistically on par with  $n_4$  (23.1 g). Nutrient level  $n_5$  resulted in the lowest seed yield per plant (21.2 g).

Table 49. Effect of nutrient levels and varieties on leaf area index at 20 DAS and 40 DAS, during *Rabi* 2023-24

Nutrient levels (N)	Leaf area index															
	20 DAS							40 DAS								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	0.67	0.68	0.62	0.62	0.61	0.60	0.63	1.99	2.08	1.93	3.40	3.50	2.42	2.30		
n <sub>2</sub>	0.68	0.61	0.57	0.64	0.60	0.59	0.62	2.11	1.99	1.95	3.83	4.36	2.10	2.54		
n <sub>3</sub>	0.61	0.59	0.62	0.62	0.62	0.60	0.61	2.01	2.00	1.86	3.42	3.46	1.93	1.91		
n <sub>4</sub>	0.60	0.58	0.63	0.62	0.63	0.58	0.61	1.55	1.61	1.19	1.76	3.32	1.47	1.82		
n <sub>5</sub>	0.66	0.62	0.59	0.63	0.63	0.61	0.62	1.39	0.99	1.00	1.89	2.06	1.10	1.41		
Mean	0.65	0.62	0.60	0.63	0.62	0.59		1.83	1.65	1.29	2.22	2.98	1.99			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.01						NS		0.13						0.424	
v	0.01						NS		0.14						0.393	
n×v	0.03						NS		0.30						0.880	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.03						NS		0.31						0.907	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 50. Effect of nutrient levels and varieties on leaf area index at 60 DAS, during *Rabi* 2023-24

Nutrient levels (N)	Leaf area index						
	60 DAS						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	4.08	5.60	4.32	5.26	6.39	4.57	5.44
n <sub>2</sub>	5.57	6.06	4.77	6.56	8.59	4.80	5.89
n <sub>3</sub>	3.36	4.92	3.45	3.38	5.43	3.55	4.02
n <sub>4</sub>	5.09	4.68	3.69	5.19	4.86	3.99	4.58
n <sub>5</sub>	4.01	3.10	2.35	3.81	3.91	3.40	3.43
Mean	4.30	4.73	4.16	5.07	5.61	4.17	
	SEm (±)		CD (0.05)				
n	0.16		0.533				
v	0.29		0.844				
n×v	0.66		1.887				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.63		1.802				

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 51. Effect of nutrient levels and varieties on chlorophyll content at 20 DAS and 40 DAS during *Rabi* 2023-24, mg g<sup>-1</sup> fresh weight

Nutrient levels (N)	Chlorophyll content															
	20 DAS							40 DAS								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	0.61	0.43	0.63	0.62	0.45	0.53	0.54	1.49	1.44	1.37	1.52	1.56	1.42	1.47		
n <sub>2</sub>	0.53	0.50	0.51	0.59	0.63	0.55	0.55	1.55	1.51	1.46	1.59	1.61	1.46	1.53		
n <sub>3</sub>	0.55	0.52	0.49	0.61	0.67	0.48	0.55	1.39	1.35	1.27	1.42	1.46	1.27	1.36		
n <sub>4</sub>	0.54	0.51	0.44	0.59	0.65	0.46	0.53	1.34	1.41	1.37	1.46	1.52	1.42	1.43		
n <sub>5</sub>	0.56	0.53	0.44	0.57	0.61	0.47	0.53	1.32	1.26	1.03	1.34	1.36	1.22	1.25		
Mean	0.56	0.52	0.47	0.60	0.64	0.48		1.43	1.39	1.30	1.47	1.50	1.36			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.01						NS		0.01						0.039	
v	0.01						0.034		0.01						0.030	
n×v	0.03						NS		0.02						0.067	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.02						NS		0.03						0.073	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 52. Effect of nutrient levels and varieties on chlorophyll content at 60 DAS during *Rabi* 2023-24, mg g<sup>-1</sup> fresh weight

Nutrient levels (N)	Chlorophyll content						
	60 DAS						
	Varieties (V)						
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	2.34	2.26	2.22	2.35	2.44	2.27	2.32
n <sub>2</sub>	2.37	2.29	2.25	2.40	2.47	2.31	2.35
n <sub>3</sub>	2.23	2.16	1.93	2.28	2.36	2.12	2.18
n <sub>4</sub>	2.25	2.23	2.15	2.33	2.39	2.22	2.26
n <sub>5</sub>	2.20	2.02	1.75	2.24	2.36	1.88	2.07
Mean	2.27	2.19	2.06	2.32	2.40	2.16	
	SEm (±)		CD (0.05)				
n	0.01		0.034				
v	0.02		0.042				
n×v	0.03		0.093				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.03		0.092				

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 53. Effect of nutrient levels and varieties on crop growth rate during *Rabi* 2023-24, g m<sup>-2</sup> d<sup>-1</sup>

Nutrient levels (N)	Crop growth rate															
	20 DAS-40 DAS							40 DAS-60 DAS								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	0.479	0.458	0.380	0.510	0.554	0.453	0.471	0.302	0.298	0.240	0.253	0.287	0.278	0.276		
n <sub>2</sub>	0.515	0.465	0.398	0.555	0.603	0.428	0.494	0.313	0.315	0.292	0.355	0.370	0.300	0.324		
n <sub>3</sub>	0.396	0.369	0.315	0.406	0.455	0.343	0.381	0.205	0.183	0.145	0.250	0.280	0.167	0.205		
n <sub>4</sub>	0.412	0.370	0.301	0.465	0.519	0.423	0.402	0.280	0.255	0.240	0.298	0.292	0.212	0.264		
n <sub>5</sub>	0.403	0.352	0.275	0.417	0.431	0.314	0.389	0.163	0.138	0.113	0.220	0.250	0.148	0.172		
Mean	0.441	0.403	0.334	0.471	0.513	0.402		0.253	0.246	0.210	0.263	0.283	0.235			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.005						0.0150		0.005						0.0160	
v	0.007						0.0180		0.008						0.0240	
n×v	0.015						0.0410		0.019						0.0530	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.014						0.0400		0.018						0.0510	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 54. Effect of nutrient levels and varieties on crop growth rate at 60 DAS to harvest during *Rabi* 2023-24, g m<sup>-2</sup> d<sup>-1</sup>

Nutrient levels (N)	Crop growth rate						
	60 DAS - Harvest						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	0.175	0.203	0.168	0.158	0.112	0.213	0.181
n <sub>2</sub>	0.245	0.230	0.205	0.257	0.273	0.225	0.243
n <sub>3</sub>	0.148	0.140	0.150	0.142	0.167	0.140	0.144
n <sub>4</sub>	0.145	0.135	0.137	0.141	0.203	0.117	0.147
n <sub>5</sub>	0.105	0.108	0.162	0.133	0.145	0.108	0.118
Mean	0.164	0.162	0.161	0.171	0.172	0.167	
	SEm (±)		CD (0.05)				
n	0.009		0.0300				
v	0.006		NS				
n×v	0.014		0.0410				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.016		0.0480				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 55. Effect of nutrient levels and varieties on relative growth rate during *Rabi* 2023-24, g g<sup>-1</sup> d<sup>-1</sup>

Nutrient levels (N)	Relative growth rate															
	20 DAS-40 DAS							40 DAS-60 DAS								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	0.146	0.143	0.138	0.149	0.151	0.147	0.145	0.022	0.021	0.023	0.022	0.025	0.019	0.021		
n <sub>2</sub>	0.150	0.149	0.143	0.151	0.156	0.145	0.149	0.027	0.023	0.020	0.029	0.030	0.024	0.025		
n <sub>3</sub>	0.143	0.142	0.133	0.146	0.148	0.138	0.142	0.020	0.019	0.018	0.023	0.023	0.016	0.020		
n <sub>4</sub>	0.141	0.139	0.134	0.143	0.146	0.136	0.140	0.021	0.020	0.022	0.021	0.021	0.020	0.022		
n <sub>5</sub>	0.136	0.133	0.123	0.140	0.143	0.129	0.134	0.017	0.016	0.016	0.020	0.022	0.018	0.018		
Mean	0.143	0.141	0.134	0.146	0.149	0.138		0.021	0.022	0.023	0.021	0.024	0.023			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.001						0.0020		0.001						0.0010	
v	0.001						0.0010		0.001						NS	
n×v	0.001						0.0020		0.002						0.0050	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.001						0.0030		0.002						0.0050	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

- n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>
- n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>
- n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>
- n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>
- n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

- v<sub>1</sub>- Kayamkulam 1
- v<sub>2</sub>- Thilathara
- v<sub>3</sub> - Thilarani
- v<sub>4</sub> - Thilak
- v<sub>5</sub> - GT 10
- v<sub>6</sub> -TMV 7

Table 56. Effect of nutrient levels and varieties on relative growth rate at 60 DAS to harvest during *Rabi* 2023-24, g g<sup>-1</sup> d<sup>-1</sup>

Nutrient levels (N)	Relative growth rate						
	60 DAS - Harvest						
	Varieties (V)						
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	0.011	0.008	0.009	0.008	0.010	0.011	0.010
n <sub>2</sub>	0.017	0.016	0.017	0.015	0.012	0.015	0.015
n <sub>3</sub>	0.009	0.009	0.010	0.008	0.008	0.009	0.009
n <sub>4</sub>	0.008	0.011	0.010	0.009	0.009	0.008	0.009
n <sub>5</sub>	0.011	0.011	0.012	0.009	0.011	0.010	0.011
Mean	0.011	0.011	0.012	0.010	0.010	0.011	
	SEm (±)		CD (0.05)				
n	0.001		0.0010				
v	0.001		NS				
n×v	0.002		NS				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.001		NS				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Among the varieties, GT 10 ( $v_5$ ) produced the highest seed yield per plant (25.4 g) which was followed by Thilak ( $v_4$ ). Thilarani resulted in the lowest seed yield per plant (20.5 g).

The interaction of nutrient levels over varieties evoked marked variation in the seed yield per plant. The combination,  $n_2v_5$  produced higher seed yield per plant (26.7 g) which was statistically on par with  $n_2v_4$  (25.9 g) and  $n_2v_1$  (25.3 g).

The interaction of varieties over nutrient levels revealed that all varieties *viz.*, Kayamkulam 1 ( $v_1$ ) (25.3 g), Thilathara ( $v_2$ ) (24.7 g), Thilarani ( $v_3$ ) (22.4 g), Thilak ( $v_4$ ) (25.9 g), GT 10 ( $v_5$ ) (26.7 g) and TMV 7 ( $v_6$ ) (23.3 g) exhibited the highest seed yield per plant at nutrient level  $n_2$ .

#### **4.2.3.6 Seed Yield $ha^{-1}$**

Seed yield  $ha^{-1}$  was significantly influenced by nutrient levels, varieties and its interactions (Table 59).

The highest seed yield  $ha^{-1}$  was observed in  $n_2$  (1051.9 kg  $ha^{-1}$ ) which was followed by  $n_1$  (929.9 kg  $ha^{-1}$ ). While, the lowest seed yield  $ha^{-1}$  was observed in  $n_5$  (853.5 kg  $ha^{-1}$ ).

Among the varieties, GT 10 ( $v_5$ ) produced the highest seed yield per hectare (1066.0 kg  $ha^{-1}$ ) which was followed by Thilak ( $v_4$ ) (983.9 kg  $ha^{-1}$ ). However, Thilarani ( $v_3$ ) resulted in the lowest seed yield  $ha^{-1}$  (802.7 kg  $ha^{-1}$ ).

The interaction effect of nutrient levels over varieties was found significant. The treatment  $n_2v_5$  produced higher seed yield  $ha^{-1}$  (1227.2 kg  $ha^{-1}$ ) which was on par with  $n_2v_4$  (1165.8 kg  $ha^{-1}$ ) and  $n_2v_1$  (1154.0 kg  $ha^{-1}$ ).

The interaction effect of varieties over nutrient levels revealed that all varieties *viz.*, Kayamkulam 1 ( $v_1$ ), Thilathara ( $v_2$ ), Thilarani ( $v_3$ ), Thilak ( $v_4$ ), GT 10 ( $v_5$ ), and TMV 7 ( $v_6$ ) produced the highest seed yield  $ha^{-1}$  at nutrient level  $n_2$  (1154.0 kg  $ha^{-1}$ , 992.3 kg  $ha^{-1}$ , 896.2 kg  $ha^{-1}$ , 1165.8 kg  $ha^{-1}$ , 1227.2 kg  $ha^{-1}$  and 893.3 kg  $ha^{-1}$ , respectively). All the varieties produced the lowest seed yield  $ha^{-1}$  at nutrient level  $n_5$ .

#### **4.2.3.7 Haulm Yield per Plant**

There was significant difference in haulm yield per plant due to the effect of nutrient levels, varieties and its interactions.

The nutrient level  $n_2$  resulted in higher haulm yield per plant (33.8 g) which was on par with  $n_1$  (32.9 g). While  $n_5$  recorded the lowest haulm yield per plant (29.0 g).

Among the varieties, GT 10 ( $v_5$ ) resulted in higher seed yield per plant (34.1 g) which was on par with Thilak ( $v_4$ ) (33.0 g). However, the lowest haulm yield per plant was noted in Thilarani ( $v_3$ ) (29.2 g).

The interaction effect of nutrient levels over varieties revealed that  $n_2v_5$  resulted in higher haulm yield per plant (37.7 g) which was on par with  $n_2v_4$  (36.5 g) and  $n_1v_5$  (35.6 g). The combination  $n_5v_3$ , resulted in the lowest haulm yield per plant (26.5 g).

The interaction effect of varieties over nutrient levels revealed that, all varieties except Thilarani ( $v_3$ ) recorded higher haulm yield per plant at nutrient level  $n_2$ . However, Thilarani produced higher haulm yield per plant at nutrient level  $n_1$ .

#### **4.2.3.8 Haulm Yield $ha^{-1}$**

Perusal of data on haulm yield  $ha^{-1}$  revealed that haulm yield  $ha^{-1}$  was significantly influenced by nutrient levels, varieties and its interaction effects.

Among the nutrient levels, higher haulm yield  $ha^{-1}$  was observed in  $n_2$  (2517 kg  $ha^{-1}$ ) which was on par with  $n_1$  (2455 kg  $ha^{-1}$ ). The lowest haulm yield  $ha^{-1}$  was observed in  $n_5$  (2182 kg  $ha^{-1}$ ).

The haulm yield  $ha^{-1}$  varied significantly among different varieties. The haulm yield  $ha^{-1}$  was noted in GT 10 ( $v_5$ ) (2502 kg  $ha^{-1}$ ) which was on par with Thilak (2430 kg  $ha^{-1}$ ). Thilarani ( $v_3$ ) resulted in the lowest haulm yield per hectare (2175 kg  $ha^{-1}$ ).

The interaction effect of nutrient levels over varieties revealed that  $n_2v_5$  resulted in higher haulm yield  $ha^{-1}$  (2840 kg  $ha^{-1}$ ) which was on par with  $n_2v_4$  (2734

kg ha<sup>-1</sup>) and n<sub>1</sub>v<sub>5</sub> (2672 kg ha<sup>-1</sup>). The treatment n<sub>5</sub>v<sub>3</sub> produced the lowest haulm yield ha<sup>-1</sup> (1973 kg ha<sup>-1</sup>).

Similar to haulm yield per plant, the interaction effect of varieties over nutrient levels showed that, all varieties except Thilarani (v<sub>3</sub>) viz., Kayamkulam 1 (v<sub>1</sub>), Thilathara (v<sub>2</sub>), Thilarani (v<sub>3</sub>), Thilak (v<sub>4</sub>), GT 10 (v<sub>5</sub>), and TMV 7 (v<sub>6</sub>) recorded higher haulm yield ha<sup>-1</sup> at nutrient level n<sub>2</sub>. However, Thilarani produced higher haulm yield ha<sup>-1</sup> at nutrient level n<sub>1</sub>.

#### **4.2.3.9 Harvest Index (HI)**

Harvest index (HI) was significantly influenced by nutrient levels, varieties and interaction effects (Table 61).

Among the nutrient levels, n<sub>2</sub> had the highest HI (0.274) which was followed by n<sub>1</sub> (0.262). Nutrient level (n<sub>5</sub>) resulted in the lowest HI (0.250).

Varieties also had significant effect on HI. Among the varieties, higher HI was observed in GT 10 (v<sub>5</sub>) (0.271) which was on par with Thilak (v<sub>4</sub>) (0.268). However, Thilarani (v<sub>3</sub>) recorded the lowest HI (0.256).

The interaction of nutrient levels over varieties was also found significant. Among the treatments, n<sub>2</sub>v<sub>5</sub> recorded higher HI (0.293) which was on par with n<sub>2</sub>v<sub>4</sub> (0.282) and n<sub>1</sub>v<sub>5</sub> (0.280). The lowest HI was recorded in the treatment n<sub>5</sub>v<sub>3</sub> (0.226).

The interaction of varieties over nutrient levels was also found significant. All varieties recorded higher HI at nutrient level n<sub>2</sub> and lower HI at n<sub>5</sub>.

#### **4.2.4 Quality Parameters**

The data pertaining to the individual and interaction effects of nutrient levels and varieties on the quality parameters of sesame are given in Tables 62, 63, 64 and 65.

##### **4.2.4.1 Oil Content**

Nutrient levels and varieties had no significant effect on the oil content of seeds.

Table 57. Effect of nutrient levels and varieties on days to 50 per cent flowering and number of capsules per plant during *Rabi* 2023-24

Nutrient levels (N)	Days to 50 per cent flowering							Number of capsules per plant						
	Varieties (V)													
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	36.3	36.0	36.7	36.3	37.3	36.0	36.4	73.3	75.0	62.3	79.3	96.0	73.3	74.9
n <sub>2</sub>	37.0	36.7	36.3	37.3	36.7	36.3	36.7	90.3	89.3	69.0	100.2	100.7	75.7	85.2
n <sub>3</sub>	36.7	36.7	36.7	35.7	37.0	36.7	36.6	66.0	64.3	60.0	68.3	88.3	64.7	71.4
n <sub>4</sub>	36.0	36.7	36.7	36.3	37.0	35.3	36.3	62.3	61.3	58.3	66.3	85.3	60.3	69.3
n <sub>5</sub>	37.0	35.3	37.7	37.3	36.0	36.3	36.6	65.7	60.3	55.0	65.0	81.0	59.7	65.6
Mean	36.6	36.3	36.8	36.6	36.8	36.1		70.1	69.1	60.3	74.0	84.0	66.7	
	SEm (±)			CD (0.05)				SEm (±)			CD (0.05)			
n	0.3			NS				n			0.2			
v	0.3			NS				v			0.1			
n×v	0.8			NS				n×v			0.2			
n(v <sub>i</sub> ×v <sub>j</sub> )	0.8			NS				n(v <sub>i</sub> ×v <sub>j</sub> )			0.3			

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 58. Effect of nutrient levels and varieties on number of seeds per capsule and hundred seed weight during *Rabi* 2023-24

Nutrient levels (N)	Number of seeds per capsule							Hundred seed weight (g)																
	Varieties (V)																							
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean										
n <sub>1</sub>	55.7	53.7	52.7	60.0	64.7	52.6	69.6	0.300	0.290	0.257	0.307	0.343	0.263	0.293										
n <sub>2</sub>	58.0	54.7	56.3	63.3	68.7	53.7	72.0	0.290	0.277	0.253	0.317	0.350	0.280	0.294										
n <sub>3</sub>	53.7	51.3	52.0	58.7	62.0	51.3	60.5	0.273	0.267	0.247	0.317	0.343	0.273	0.287										
n <sub>4</sub>	54.3	52.0	51.3	60.7	64.0	51.7	62.0	0.290	0.277	0.250	0.310	0.340	0.253	0.282										
n <sub>5</sub>	53.0	51.0	50.3	57.0	60.3	50.2	55.0	0.270	0.280	0.263	0.310	0.343	0.273	0.285										
Mean	54.9	53.7	51.6	60.1	65.1	52.5		0.285	0.278	0.254	0.312	0.344	0.269											
	SEm (±)						CD (0.05)						SEm (±)						CD (0.05)					
n	0.4						1.39						0.002						NS					
v	0.9						2.54						0.003						0.0080					
n×v	2.0						NS						0.006						NS					
n(v <sub>i</sub> ×v <sub>j</sub> )	1.9						NS						0.006						NS					

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 59. Effect of nutrient levels and varieties on seed yield during *Rabi* 2023-24

Nutrient levels (N)	Seed yield (g per plant)							Seed yield (kg ha <sup>-1</sup> )						
	Varieties (V)													
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	24.4	23.9	21.6	24.5	24.8	22.9	23.6	983.0	960.0	833.7	1085.5	1148.4	878.8	929.9
n <sub>2</sub>	25.3	24.7	22.4	25.9	26.7	23.3	24.8	1154.0	992.3	896.2	1165.8	1227.2	893.3	1051.9
n <sub>3</sub>	23.4	23.1	20.4	23.1	24.4	21.9	22.2	867.3	885.8	783.3	946.8	1049.5	815.2	867.9
n <sub>4</sub>	23.9	22.8	21.5	24.0	25.1	22.5	23.1	886.5	897.3	809.4	954.8	1070.6	842.6	919.9
n <sub>5</sub>	22.1	22.9	19.3	22.8	23.4	20.7	21.2	849.9	838.3	690.7	873.4	933.8	728.4	853.5
Mean	23.6	22.5	20.5	24.6	25.4	21.3		946.3	917.3	802.7	983.9	1066.0	831.6	
	SEm (±)						CD (0.05)	SEm (±)						CD (0.05)
n	0.3						1.05	16.5						53.81
v	0.2						0.65	12.1						34.43
n×v	0.5						1.45	27.1						76.98
n(v <sub>i</sub> ×v <sub>j</sub> )	0.6						1.69	29.7						88.34

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 60. Effect of nutrient levels and varieties on haulm yield during *Rabi* 2023-24

Nutrient levels (N)	Haulm yield (g per plant)							Haulm yield (kg ha <sup>-1</sup> )								
	Varieties (V)															
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean		
n <sub>1</sub>	32.8	31.7	31.6	33.9	35.6	31.0	32.9	2458	2451	2278	2653	2672	2305	2455		
n <sub>2</sub>	34.2	32.9	31.1	36.5	37.7	31.8	33.8	2520	2554	2242	2734	2840	2351	2517		
n <sub>3</sub>	31.9	30.4	27.4	31.4	33.4	29.8	30.6	2372	2163	2053	2395	2517	2168	2295		
n <sub>4</sub>	32.0	31.5	29.5	33.1	34.5	30.6	31.9	2447	2286	2128	2507	2548	2217	2301		
n <sub>5</sub>	29.6	29.7	26.5	30.2	30.4	27.9	29.0	2081	2055	1973	2161	2190	1992	2182		
Mean	31.9	31.7	29.2	33.0	34.1	30.4		2336	2320	2175	2430	2502	2207			
	SEm (±)						CD (0.05)						SEm (±)		CD (0.05)	
n	0.3						1.08						n		20	
v	0.4						0.96						v		29	
n×v	0.7						2.14						n×v		65	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.8						2.23						n(v <sub>i</sub> ×v <sub>j</sub> )		62	

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 61. Effect of nutrient levels and varieties on harvest index during *Rabi* 2023-24

Nutrient levels (N)	Harvest index						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	0.268	0.264	0.263	0.270	0.280	0.260	0.262
n <sub>2</sub>	0.270	0.269	0.265	0.282	0.293	0.265	0.274
n <sub>3</sub>	0.258	0.262	0.257	0.249	0.262	0.239	0.256
n <sub>4</sub>	0.262	0.263	0.261	0.255	0.269	0.250	0.261
n <sub>5</sub>	0.241	0.260	0.226	0.249	0.257	0.232	0.250
Mean	0.260	0.259	0.256	0.268	0.271	0.258	
	SEm (±)		CD (0.05)				
n	0.003		0.0110				
v	0.004		0.0100				
n×v	0.007		0.0220				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.008		0.0230				

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

#### **4.2.4.2 Crude Protein Content**

The nutrient levels and varieties could not bring any significant changes in the crude protein content of the seeds.

#### **4.2.4.3 Phosphorus (P) Content**

The data on P content as influenced by nutrient levels, varieties and interactions are shown in Table 63.

Among the nutrient levels, P content was found to be higher in  $n_2$  (0.482%) which was on par with  $n_1$  (0.477%) and  $n_3$  (0.460%). The lowest P content was observed in  $n_5$  (0.401%).

Amongst varieties, GT 10 ( $v_5$ ) recorded higher P content (0.516%) which was on par with Thilak ( $v_4$ ) (0.501%) and Kayamkulam 1 ( $v_1$ ) (0.491%).

The interaction of nutrients over varieties and vice-versa were not significant.

#### **4.2.4.4 Calcium (Ca) Content**

Nutrient levels and varieties had significant effect on calcium content of seeds, but the interactions were not significant (Table 63).

Amongst nutrient levels,  $n_2$  resulted in higher Ca content (0.522%) which was on par with  $n_1$  (0.510%). The lowest Ca content was noted in  $n_5$  (0.467%).

Similarly, among the varieties, GT 10 ( $v_5$ ) recorded higher Ca content (0.533%) which was on par with Thilak ( $v_4$ ) (0.512%). However, Thilarani ( $v_3$ ) had the lowest Ca content in the seeds (0.452%).

#### **4.2.4.5 Magnesium (Mg) Content**

The variations in Mg content of sesame seeds due to the effect of nutrient levels, varieties and its interactions are presented in Table 64.

The highest Mg content was recorded in nutrient level,  $n_2$  (0.309%) which was followed by  $n_1$  (0.295%). The lowest Mg content was observed in  $n_5$  (0.271%).

Among the varieties, GT10 ( $v_5$ ) had higher Mg content (0.314%) which was on par with Thilak ( $v_4$ ) (0.307%). However, the lowest Mg content was observed in Thilarani ( $v_3$ ) (0.263%).

The interaction of nutrient levels over varieties were found significant. Among the interactions,  $n_2v_4$  recorded higher Mg content (0.332%) which was on par with  $n_2v_5$  (0.330%),  $n_1v_4$  (0.321%) and  $n_1v_5$  (0.310%).

Similarly, interaction of varieties over nutrient levels were also found significant. All varieties except TMV 7 ( $v_6$ ) recorded higher Mg content at nutrient level  $n_2$ . The variety  $v_6$  recorded higher Mg content at nutrient level  $n_1$ .

#### **4.2.4.6 Iron (Fe) Content**

Perusal of the data on Fe content revealed that nutrient levels and varieties had significant effect on Fe content, but its interactions are not significant (Table 64).

Amongst nutrient levels,  $n_2$  resulted in higher Fe content (0.058%) which was followed by  $n_1$  (0.053%). The lowest Fe content was observed in  $n_3$  (0.049%).

Among the varieties, GT 10 ( $v_5$ ) had higher Fe content (0.059%) which was on par with Thilak ( $v_4$ ) (0.057%) and Kayamkulam 1 ( $v_1$ ) (0.054%).

#### **4.2.4.7 Zinc (Zn) Content**

The results on the influence of nutrient levels and varieties on Zn content are presented in Table 65.

Among the nutrient levels, higher Zn content was observed in  $n_2$  (0.038%) which was on par with  $n_1$  (0.037%). The lowest Zn content was observed in  $n_5$  (0.030%).

Varieties had no significant effect on the Zn content of sesame seed.

The interaction of nutrient levels over varieties revealed that  $n_2v_5$  recorded higher Zn content (0.042%) which was on par with  $n_2v_4$  (0.041%),  $n_1v_5$  (0.040%) and  $n_1v_4$  (0.039%). The treatment,  $n_5v_3$  had the lowest Zn content (0.026%).

Table 62. Effect of nutrient levels and varieties on oil content and crude protein content in seeds during *Rabi* 2023-24, %

Nutrient levels (N)	Oil content							Crude protein						
	Varieties (V)													
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	41.80	42.23	42.37	41.17	42.60	40.43	41.77	20.42	20.50	21.37	22.04	22.17	19.79	21.05
n <sub>2</sub>	42.30	41.63	40.43	41.20	42.33	41.87	41.63	20.98	22.21	21.04	19.60	21.18	19.94	20.83
n <sub>3</sub>	41.10	40.73	42.47	41.03	42.47	40.60	41.40	19.35	21.08	21.05	21.46	21.17	19.83	20.66
n <sub>4</sub>	40.90	41.67	39.97	40.70	40.90	40.96	40.85	21.04	21.25	19.79	21.39	19.67	20.77	20.65
n <sub>5</sub>	40.20	40.63	39.60	40.97	41.67	40.27	40.56	20.39	20.21	21.21	19.79	19.96	19.45	20.17
Mean	41.26	41.28	40.97	41.01	41.99	40.83		20.44	21.05	20.89	20.65	20.83	19.96	
	SEm (±)						CD (0.05)	SEm (±)						CD (0.05)
n	0.58						NS	0.40						NS
v	0.52						NS	0.38						NS
n×v	1.16						NS	0.84						NS
n(v <sub>i</sub> ×v <sub>j</sub> )	1.17						NS	0.87						NS

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 63. Effect of nutrient levels and varieties on Phosphorus and Calcium content in seeds during *Rabi* 2023-24, %

Nutrient levels (N)	Phosphorus (P) content in seeds							Calcium (Ca) content in seeds								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	0.503	0.463	0.357	0.517	0.537	0.430	0.477	0.505	0.515	0.458	0.529	0.552	0.467	0.510		
n <sub>2</sub>	0.525	0.477	0.390	0.547	0.577	0.433	0.482	0.502	0.500	0.474	0.574	0.588	0.496	0.522		
n <sub>3</sub>	0.470	0.447	0.347	0.520	0.520	0.397	0.460	0.507	0.498	0.464	0.533	0.530	0.480	0.500		
n <sub>4</sub>	0.467	0.433	0.353	0.480	0.500	0.403	0.439	0.508	0.495	0.433	0.457	0.468	0.442	0.478		
n <sub>5</sub>	0.433	0.423	0.307	0.443	0.447	0.353	0.401	0.495	0.479	0.434	0.465	0.526	0.469	0.467		
Mean	0.491	0.449	0.351	0.501	0.516	0.403		0.503	0.497	0.452	0.512	0.533	0.471			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.012						0.0401		0.010						0.0191	
v	0.010						0.0340		0.010						0.0210	
n×v	0.020						NS		0.020						NS	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.030						NS		0.020						NS	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 64. Effect of nutrient levels and varieties on Magnesium and Iron content in seeds during *Rabi* 2023-24, %

Nutrient levels (N)	Magnesium (Mg) content in seeds							Iron (Fe) content in seeds						
	Varieties (V)													
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	0.295	0.294	0.285	0.321	0.310	0.290	0.295	0.051	0.048	0.042	0.056	0.040	0.045	0.053
n <sub>2</sub>	0.301	0.302	0.291	0.332	0.330	0.278	0.309	0.064	0.060	0.059	0.060	0.054	0.058	0.058
n <sub>3</sub>	0.270	0.290	0.257	0.296	0.302	0.280	0.288	0.048	0.047	0.055	0.050	0.042	0.057	0.049
n <sub>4</sub>	0.266	0.244	0.235	0.251	0.298	0.275	0.291	0.057	0.043	0.044	0.058	0.051	0.050	0.051
n <sub>5</sub>	0.257	0.250	0.224	0.250	0.290	0.272	0.271	0.053	0.051	0.055	0.051	0.050	0.053	0.050
Mean	0.294	0.286	0.263	0.307	0.314	0.280		0.054	0.051	0.050	0.057	0.059	0.052	
	SEm (±)						CD (0.05)	SEm (±)						CD (0.05)
n	0.003						0.0100	0.001						0.0030
v	0.005						0.0130	0.002						0.0050
n×v	0.010						0.0290	0.000						NS
n(v <sub>i</sub> ×v <sub>j</sub> )	0.009						0.0280	0.000						NS

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 65. Effect of nutrient levels and varieties on Zinc content in the seeds during *Rabi* 2023-24, %

Nutrient levels (N)	Zinc (Zn) content in seeds						
	Varieties (V)						
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	0.034	0.035	0.033	0.039	0.040	0.034	0.037
n <sub>2</sub>	0.037	0.036	0.034	0.041	0.042	0.035	0.038
n <sub>3</sub>	0.030	0.033	0.033	0.036	0.037	0.032	0.033
n <sub>4</sub>	0.035	0.033	0.031	0.032	0.036	0.031	0.034
n <sub>5</sub>	0.029	0.027	0.026	0.030	0.032	0.028	0.030
Mean	0.035	0.034	0.035	0.036	0.035	0.034	
	SEm (±)		CD (0.05)				
n	0.001		0.0020				
v	0.000		NS				
n×v	0.002		0.0040				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.002		0.0050				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

The interaction of varieties over nutrient levels revealed that all the varieties recorded higher Zn content at nutrient level  $n_2$  and the lowest Zn content at nutrient level  $n_5$ .

#### **4.2.5 Plant Analysis**

The effect of nutrient levels and varieties on N, P and K uptake by sesame are depicted in Tables 66, 67, 68, 69, 70 and 71.

##### **4.2.6.1 N Uptake**

Perusal of data revealed that the N uptake by seed, haulm and total N uptake were higher at nutrient level  $n_2$ , (35.4 kg ha<sup>-1</sup>, 55.5 kg ha<sup>-1</sup>, and 90.9 kg ha<sup>-1</sup>, respectively). However, N uptake by seed and total N uptake were significantly superior over other nutrient levels. While the N uptake by haulm was on par with  $n_1$  (53.1 kg ha<sup>-1</sup>).

Among the varieties, the highest N uptake by the seed, haulm and total uptake were observed in GT 10 ( $v_5$ ) (37.6 kg ha<sup>-1</sup>, 59.8 kg ha<sup>-1</sup> and 97.4 kg ha<sup>-1</sup> respectively).

Comparing the interaction of nutrient levels over varieties revealed that N uptake by seed, haulm and total N uptake were higher in  $n_2v_5$  (43.9 kg ha<sup>-1</sup>, 71.1 kg ha<sup>-1</sup> and 115.0 kg ha<sup>-1</sup>). The N uptake by seed and total N uptake were significantly superior over other treatments. However, N uptake by haulm was on par with  $n_2v_4$  (67.6 kg ha<sup>-1</sup>).

The interaction of varieties over nutrient levels revealed that all varieties recorded the highest N uptake by seed, haulm and total uptake at nutrient level  $n_2$ . However, the lowest N uptake by seed, haulm and total uptake were noted in  $n_5$ .

##### **4.2.6.2 P Uptake**

Similar to that of N uptake, P uptake by seed, haulm and total P uptake were higher in  $n_2$  (7.5 kg ha<sup>-1</sup>, 12.2 kg ha<sup>-1</sup>, and 19.7 kg ha<sup>-1</sup>). However, P uptake by seed and total P uptake were significantly superior over treatments. While P uptake by

haulm was on par with  $n_1$  (12.1 kg ha<sup>-1</sup>). Among the nutrient levels,  $n_5$  resulted in the lowest P uptake by seed, haulm and total P uptake.

Among the different varieties, P uptake by seed, haulm and total uptake were significantly the highest in GT 10 ( $v_5$ ) (8.1 kg ha<sup>-1</sup>, 12.4 kg ha<sup>-1</sup> and 20.5 kg ha<sup>-1</sup>, respectively). The nutrient level  $n_5$  resulted in the lowest P uptake by seed, haulm and total P uptake.

The interaction effect of nutrient levels over varieties were significant only for P uptake by haulm and total P uptake. The P uptake by the haulm was higher in  $n_2v_5$  (12.7 kg ha<sup>-1</sup>) which was on par with  $n_2v_4$  (12.6 kg ha<sup>-1</sup>),  $n_2v_1$  (12.6 kg ha<sup>-1</sup>) and  $n_1v_5$  (12.5 kg ha<sup>-1</sup>). While, the total P uptake was significantly higher in  $n_2v_5$  (21.8 kg ha<sup>-1</sup>).

Similarly, the interaction effect of varieties over nutrient levels revealed that  $n_2$  resulted in higher P uptake by haulm and total P uptake in all the varieties except TMV 7 ( $v_6$ ). However,  $v_6$  recorded higher P uptake by haulm at nutrient level  $n_1$ .

#### **4.2.6.3 K Uptake**

Amongst nutrient levels, K uptake by seed, haulm and total uptake were significantly higher in  $n_2$  (16.4 kg ha<sup>-1</sup>, 41.0 kg ha<sup>-1</sup> and 57.4 kg ha<sup>-1</sup> respectively). It was followed by  $n_1$  and the lowest K uptake by seed, haulm and total uptake were noted in  $n_5$ .

Among the varieties, GT 10 had the highest K uptake by seed, haulm and total K uptake (16.5 kg ha<sup>-1</sup>, 44.0 kg ha<sup>-1</sup> and 60.5 kg ha<sup>-1</sup> respectively) and it was followed by Thilak ( $v_4$ ). Thilarani ( $v_3$ ) had the lowest K uptake by seed, haulm and total K uptake.

The interaction of nutrient levels over varieties was significant only for K uptake by seed. Among the treatments,  $n_2v_5$  had higher K uptake by seed (18.9 kg ha<sup>-1</sup>) which was on par with  $n_1v_5$  (18.5 kg ha<sup>-1</sup>). The treatment  $n_5v_3$  recorded the lowest K uptake by seed (10.8 kg ha<sup>-1</sup>).

Table 66. Effect of nutrient levels and varieties on nitrogen uptake by seed and haulm during *Rabi* 2023-24, kg ha<sup>-1</sup>

Nutrient levels (N)	Nitrogen uptake															
	Seed							Haulm								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	32.1	30.3	26.0	32.1	41.2	27.7	32.4	53.2	50.9	42.7	59.5	63.7	47.3	53.1		
n <sub>2</sub>	35.4	32.5	30.4	38.5	43.9	31.6	35.4	54.8	53.0	43.4	67.6	71.1	48.3	55.5		
n <sub>3</sub>	32.0	27.4	24.4	31.9	36.4	26.9	29.8	46.9	42.8	36.4	49.4	54.2	45.1	49.0		
n <sub>4</sub>	31.2	29.3	24.5	33.1	37.2	27.3	30.3	44.4	44.9	42.4	54.9	59.7	46.1	45.4		
n <sub>5</sub>	28.2	26.7	23.6	30.5	33.4	25.5	28.3	38.7	39.1	35.1	45.4	50.4	39.2	40.8		
Mean	31.6	29.4	25.4	33.2	37.6	27.8		47.6	46.2	39.4	54.6	59.8	50.0			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.7						2.12		0.8						2.50	
v	0.4						1.17		0.7						1.95	
n×v	0.9						2.62		1.5						4.36	
n(v <sub>i</sub> ×v <sub>j</sub> )	1.1						3.19		1.6						4.69	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 67. Effect of nutrient levels and varieties on total nitrogen uptake during *Rabi* 2023-24, kg ha<sup>-1</sup>

Nutrient levels (N)	Total nitrogen uptake						
	Varieties (V)						
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	85.3	81.2	68.7	91.6	104.9	75.0	85.5
n <sub>2</sub>	90.1	85.5	73.8	106.0	115.0	80.0	90.9
n <sub>3</sub>	78.9	70.2	60.8	81.3	90.6	72.0	78.8
n <sub>4</sub>	75.6	74.2	66.9	88.0	96.9	73.4	75.7
n <sub>5</sub>	67.0	65.8	58.7	75.9	83.7	64.6	69.1
Mean	79.2	75.6	64.8	87.8	97.4	72.8	
	SEm (±)		CD (0.05)				
n	1.4		4.45				
v	0.9		2.56				
n×v	2.0		5.72				
n(v <sub>i</sub> ×v <sub>j</sub> )	2.3		6.84				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 68. Effect of nutrient levels and varieties on phosphorus uptake by seed and haulm during *Rabi* 2023-24, kg ha<sup>-1</sup>

Nutrient levels (N)	Phosphorus uptake															
	Seed							Haulm								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	7.5	7.0	6.3	7.8	8.3	6.9	7.2	12.4	12.0	11.6	12.4	12.5	11.9	12.1		
n <sub>2</sub>	7.7	7.3	6.6	8.3	9.0	7.8	7.5	12.6	12.1	11.7	12.6	12.7	11.6	12.2		
n <sub>3</sub>	7.1	6.6	6.2	7.5	7.6	6.5	6.9	12.1	11.9	10.9	11.2	12.2	11.8	11.9		
n <sub>4</sub>	7.3	7.1	6.1	7.6	7.9	6.5	7.1	12.2	12.0	11.5	12.2	12.3	11.7	12.0		
n <sub>5</sub>	6.8	7.0	5.9	7.3	7.5	6.6	6.8	12.1	11.7	9.0	12.1	12.2	10.6	11.5		
Mean	7.3	7.0	6.2	7.7	8.1	6.7		12.2	12.0	11.1	12.2	12.4	11.8			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.1						0.20		0.1						0.15	
v	0.1						0.23		0.1						0.13	
n×v	0.2						NS		0.1						0.28	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.2						NS		0.1						0.30	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 69. Effect of nutrient levels and varieties on total phosphorus uptake during *Rabi* 2023-24, kg ha<sup>-1</sup>

Nutrient levels (N)	Total phosphorus uptake						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	19.9	19.1	18.1	20.2	20.8	18.8	19.3
n <sub>2</sub>	20.2	19.4	18.4	20.9	21.8	19.4	19.7
n <sub>3</sub>	19.2	18.4	17.1	18.7	19.8	18.4	18.9
n <sub>4</sub>	19.5	19.0	17.6	19.9	20.2	18.2	19.1
n <sub>5</sub>	18.9	18.8	14.9	19.5	19.7	17.3	18.3
Mean	19.5	19.0	17.3	19.9	20.5	18.5	
	SEm (±)		CD (0.05)				
n	0.1		0.14				
v	0.1		0.26				
n×v	0.2		0.58				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.2		0.55				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>  
n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>  
n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>  
n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>  
n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1  
v<sub>2</sub>- Thilathara  
v<sub>3</sub> - Thilarani  
v<sub>4</sub> - Thilak  
v<sub>5</sub> - GT 10  
v<sub>6</sub> -TMV 7

Table 70. Effect of nutrient levels and varieties on potassium uptake by seed and haulm during *Rabi* 2023-24, kg ha<sup>-1</sup>

Nutrient levels (N)	Potassium uptake															
	Seed							Haulm								
	Varieties (V)															
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean		
n <sub>1</sub>	15.9	15.8	13.9	15.2	18.5	14.1	15.1	37.9	36.7	34.7	42.4	46.9	35.2	38.8		
n <sub>2</sub>	16.6	15.9	14.2	17.4	18.9	15.1	16.4	38.6	39.8	35.6	45.0	48.1	37.6	41.0		
n <sub>3</sub>	14.7	14.5	13.8	15.4	15.7	14.1	14.8	35.8	34.9	31.5	39.3	42.5	34.6	36.9		
n <sub>4</sub>	15.6	14.6	13.2	16.3	16.7	13.4	14.6	36.8	35.3	33.0	41.0	44.6	35.8	37.3		
n <sub>5</sub>	14.8	14.3	10.8	15.6	15.2	14.1	14.2	34.6	32.4	30.2	38.3	40.0	31.2	35.3		
Mean	15.5	15.0	13.2	16.0	16.5	14.2		37.2	35.8	33.0	41.2	44.0	35.9			
	SEm (±)						CD (0.05)		SEm (±)						CD (0.05)	
n	0.1						0.28		0.3						1.06	
v	0.1						0.28		0.5						1.36	
n×v	0.2						0.63		1.1						NS	
n(v <sub>i</sub> ×v <sub>j</sub> )	0.2						0.63		1.0						NS	

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 71. Effect of nutrient levels and varieties on total potassium uptake during *Rabi* 2023-24, kg ha<sup>-1</sup>

Nutrient levels (N)	Total potassium uptake						
	Varieties (V)						
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	53.8	52.5	48.6	57.6	63.4	49.3	53.9
n <sub>2</sub>	55.3	55.7	49.8	62.3	67.0	53.7	57.4
n <sub>3</sub>	50.5	49.4	45.3	54.8	58.2	48.8	51.7
n <sub>4</sub>	52.4	49.9	43.8	57.3	61.3	49.2	51.9
n <sub>5</sub>	49.4	46.7	43.4	53.9	55.2	45.3	49.5
Mean	52.7	50.8	46.2	57.2	60.5	50.1	
	SEm (±)		CD (0.05)				
n	0.4		1.18				
v	0.5		1.42				
n×v	1.1		NS				
n(v <sub>i</sub> ×v <sub>j</sub> )	1.1		NS				

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Similarly, the interaction of varieties over nutrient levels showed that all varieties *viz.*, Kayamkulam1 ( $v_1$ ) (16.6 kg ha<sup>-1</sup>), Thilathara ( $v_2$ ) (15.9 kg ha<sup>-1</sup>), Thilarani ( $v_3$ ) (14.2 kg ha<sup>-1</sup>), Thilak ( $v_4$ ) (17.4 kg ha<sup>-1</sup>), GT 10 ( $v_5$ ) (18.9 kg ha<sup>-1</sup>) and TMV 7 ( $v_6$ ) (15.1 kg ha<sup>-1</sup>) recorded higher K uptake by the seed at nutrient level  $n_2$ .

#### **4.2.6 Soil Analysis**

The results on post experiment soil organic carbon, available N, P and K as influenced by nutrient levels, varieties and its interaction are presented in Tables 72 and 73.

##### **4.2.5.1 Organic Carbon**

Nutrient levels and varieties did not have any significant effect on organic carbon content of the soil.

##### **4.2.5.2 Available Nitrogen**

Available N content in the post-harvest soil was significantly influenced by nutrient levels, varieties and its interactions.

Perusal of data on available N in post experiment soil revealed that  $n_2$  resulted in higher available N in the soil (193.7 kg ha<sup>-1</sup>) which was on par with  $n_1$  (191.1 kg ha<sup>-1</sup>) and  $n_4$  (188.1 kg ha<sup>-1</sup>). While the lowest available N was observed in  $n_5$  (174.8 kg ha<sup>-1</sup>).

Amongst varieties, the highest available N was observed in GT 10 ( $v_5$ ) (212.2 kg ha<sup>-1</sup>) which was followed by Thilak ( $v_4$ ). The lowest available N in the soil was noted in Thilarani ( $v_3$ ) (155.1 kg ha<sup>-1</sup>).

The interaction of nutrient levels over varieties was found significant and among the interactions,  $n_2v_5$  recorded higher available N (222.5 kg ha<sup>-1</sup>) which was on par with  $n_1v_5$  (220.6 kg ha<sup>-1</sup>),  $n_4v_5$  (217.4 kg ha<sup>-1</sup>),  $n_2v_4$  (215.3 kg ha<sup>-1</sup>),  $n_1v_4$  (211.8 kg ha<sup>-1</sup>),  $n_4v_4$  (210.3 kg ha<sup>-1</sup>) and  $n_3v_4$  (203.6 kg ha<sup>-1</sup>). The lowest available N in the soil was observed in the treatment  $n_5v_3$  (149.7 kg ha<sup>-1</sup>).

Similarly, interaction of varieties over nutrient levels was also significant. The results revealed that all the varieties, Thilathara ( $v_2$ ), Thilarani ( $v_3$ ), Thilak ( $v_4$ ),

GT10 (v<sub>5</sub>) and TMV 7 (v<sub>6</sub>) recorded higher available soil N at nutrient level n<sub>2</sub> (196.1 kg ha<sup>-1</sup>, 160.6 kg ha<sup>-1</sup>, 215.3 kg ha<sup>-1</sup>, 222.5 kg ha<sup>-1</sup> and 186.1 kg ha<sup>-1</sup>). While Kayamkulam 1 (v<sub>1</sub>) recorded higher available N at nutrient level n<sub>1</sub> (197.4 kg ha<sup>-1</sup>).

#### **4.2.5.3 Available Phosphorus**

Similar to that of available N, available P in the soil was also significantly influenced by nutrient levels and varieties.

Among the nutrient levels, n<sub>2</sub> recorded higher soil available P (29.1 kg ha<sup>-1</sup>) which was on par with n<sub>1</sub> (28.5 kg ha<sup>-1</sup>). The lowest available P in the soil was noted in n<sub>5</sub> (25.3 kg ha<sup>-1</sup>).

Among the varieties, GT 10 recorded the highest available P (28.4 kg ha<sup>-1</sup>) which was followed by Thilak (27.3 kg ha<sup>-1</sup>). The lowest available P in the post-harvest soil was noted in Thilarani (24.5 kg ha<sup>-1</sup>).

No significant interaction was observed between the nutrient levels and varieties.

#### **4.2.5.4 Available Potassium**

Potassium content in soil varied significantly with nutrient levels and varieties.

Among the nutrient levels n<sub>2</sub> resulted in higher available K in the post-harvest soil (145.8 kg ha<sup>-1</sup>) which was on par with n<sub>1</sub> (142.4 kg ha<sup>-1</sup>). The lowest available K in the post-experiment soil was observed in n<sub>5</sub> (134.2 kg ha<sup>-1</sup>).

Among the varieties, GT 10 (v<sub>5</sub>) resulted in higher available K in the soil (149.5 kg ha<sup>-1</sup>) which was on par with Thilak (v<sub>4</sub>) (145.1 kg ha<sup>-1</sup>). Thilarani (v<sub>3</sub>) had the lowest available K in the soil (128.8 kg ha<sup>-1</sup>).

Interaction effects were found not significant.

#### **4.2.7 Economics**

The results pertaining to the effect of nutrient levels and varieties on economics of cultivation are given in Tables 74, 75 and 76.

Table 72. Effect of nutrient levels and varieties on organic carbon and available N during *Rabi* 2023-24

Nutrient levels (N)	Organic carbon (%)							Available N (kg ha <sup>-1</sup> )						
	Varieties (V)													
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	0.82	0.80	0.81	0.86	0.83	0.77	0.81	197.4	193.6	159.3	211.8	220.6	184.0	191.1
n <sub>2</sub>	0.93	0.84	0.79	0.83	0.84	0.82	0.84	185.7	196.1	160.6	215.3	222.5	186.1	193.7
n <sub>3</sub>	0.79	0.88	0.87	0.80	0.83	0.83	0.83	180.6	182.3	152.0	203.6	202.8	179.4	182.7
n <sub>4</sub>	0.88	0.84	0.84	0.80	0.83	0.83	0.84	177.7	191.1	155.1	210.3	217.4	181.5	188.1
n <sub>5</sub>	0.85	0.85	0.78	0.89	0.79	0.81	0.83	174.4	176.0	149.7	172.3	196.5	175.2	174.8
Mean	0.86	0.84	0.82	0.84	0.83	0.81		183.1	192.2	155.1	199.1	212.2	181.2	
	SEm (±)			CD (0.05)				SEm (±)			CD (0.05)			
n	0.01			NS				n			3.0			
v	0.02			NS				v			3.1			
n×v	0.04			NS				n×v			6.9			
n(v <sub>i</sub> ×v <sub>j</sub> )	0.03			NS				n(v <sub>i</sub> ×v <sub>j</sub> )			7.0			

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 73. Effect of nutrient levels and varieties on available P and K during *Rabi* 2023-24

Nutrient levels (N)	Available P (kg ha <sup>-1</sup> )							Available K (kg ha <sup>-1</sup> )						
	Varieties (V)													
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>5</sub>	V <sub>6</sub>	Mean
n <sub>1</sub>	27.8	27.0	24.6	28.2	28.9	25.7	28.5	132.0	139.2	134.0	147.4	149.4	134.5	142.4
n <sub>2</sub>	29.0	28.8	27.2	30.7	30.7	28.0	29.1	131.9	136.9	126.1	143.6	147.1	130.6	145.8
n <sub>3</sub>	26.2	25.9	23.5	27.4	28.1	25.1	26.0	131.3	140.7	125.8	144.0	145.2	126.4	135.6
n <sub>4</sub>	27.0	26.2	24.4	28.1	29.6	25.7	26.8	143.1	146.8	133.9	150.9	168.1	132.1	136.0
n <sub>5</sub>	25.5	24.8	22.7	27.3	27.7	24.0	25.3	128.4	142.2	124.1	139.8	137.8	133.0	134.2
Mean	26.1	26.5	24.5	27.3	28.4	25.7		133.3	141.1	128.8	145.1	149.5	131.3	
	SEm (±)			CD (0.05)				SEm (±)			CD (0.05)			
n	0.2			0.71				n			1.5			
v	0.3			0.54				v			1.9			
n×v	0.4			NS				n×v			4.3			
n(v <sub>i</sub> ×v <sub>j</sub> )	0.4			NS				n(v <sub>i</sub> ×v <sub>j</sub> )			4.2			

\*NS- Non Significant

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

#### **4.2.7.1 Gross Return**

Among the nutrient levels, gross return was significantly higher in  $n_2$  (₹ 84153 ha<sup>-1</sup>) and among the varieties, GT 10 recorded the highest gross return (₹ 85278 ha<sup>-1</sup>).

The interaction effect of nutrient levels over varieties revealed that,  $n_2v_5$  recorded the highest gross return (₹ 98176 ha<sup>-1</sup>) which was followed by  $n_2v_4$ . The lowest gross return was noted in  $n_5v_3$ .

While, the interaction effect of varieties over nutrient levels showed that all varieties recorded higher gross return at nutrient level  $n_2$ .

#### **4.2.7.2 Net Return**

Among the nutrient levels, the net return was significantly higher for  $n_2$  (₹ 46270 ha<sup>-1</sup>). While among the varieties, GT 10 had the highest net return (₹ 50501 ha<sup>-1</sup>).

The interaction effect of nutrient levels over varieties revealed that,  $n_2v_5$  recorded the highest net return (₹ 60293 ha<sup>-1</sup>) and the lowest in  $n_3v_3$ .

The interaction effect of varieties over nutrient levels revealed that all varieties recorded higher net return at nutrient level  $n_2$ .

#### **4.2.7.3 B:C Ratio**

Among the nutrient levels, the B:C ratio was significantly higher in  $n_2$  (2.2) and among the varieties GT 10 recorded the highest B:C ratio (2.6).

The interaction effect of nutrient levels over varieties revealed that,  $n_2v_5$  recorded the highest B: C ratio (2.6).

The interaction effect of varieties over nutrient levels revealed that all varieties recorded higher B:C ratio at nutrient level  $n_2$ .

### **4.3 ASSESSMENT OF ALLELOPATHIC POTENTIAL OF SESAME**

#### **4.3.1 Assessment of Allelopathic Effect of Sesame on Selected Weeds**

Table 74. Effect of nutrient levels and varieties on gross return during *Rabi* 2023-24, ₹ ha<sup>-1</sup>

Nutrient levels (N)	Gross return						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	70919	78639	64750	75741	85260	70306	74393
n <sub>2</sub>	91602	79380	71694	91345	98176	71463	84153
n <sub>3</sub>	69380	70867	55259	78843	83963	58269	69430
n <sub>4</sub>	78639	70982	66694	75750	84287	65213	73594
n <sub>5</sub>	67991	67065	62667	69872	74704	67403	68284
Mean	75706	73386	64213	78710	85278	665301	
		SEM (±)		CD (0.05)			
n		1319		4304.4			
v		969		2753.9			
n×v		2167		6158.0			
n(v <sub>i</sub> ×v <sub>j</sub> )		2378		7065.1			

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 75. Effect of nutrient levels and varieties on net return during *Rabi* 2023-24, ₹ ha<sup>-1</sup>

Nutrient levels (N)	Net return						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	36936	40756	30767	41758	51277	33580	40410
n <sub>2</sub>	53719	45397	33811	53463	60293	36323	46270
n <sub>3</sub>	35456	36943	21335	44919	50039	24345	35506
n <sub>4</sub>	44669	37012	32724	41780	50317	31243	39624
n <sub>5</sub>	33866	32940	28542	35747	40579	33278	34159
Mean	40929	38609	29436	43933	50501	31754	
	SEm (±)		CD (0.05)				
n	1319		4304.4				
v	969		2753.9				
n×v	2167		6158.0				
n(v <sub>i</sub> ×v <sub>j</sub> )	2378		7065.1				

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Table 76. Effect of nutrient levels and varieties on B:C ratio during *Rabi* 2023-24

Nutrient levels (N)	B:C ratio						
	Varieties (V)						
	v <sub>1</sub>	v <sub>2</sub>	v <sub>3</sub>	v <sub>4</sub>	v <sub>5</sub>	v <sub>6</sub>	Mean
n <sub>1</sub>	2.1	2.1	1.8	2.2	2.4	1.9	2.0
n <sub>2</sub>	2.4	2.3	2.0	2.4	2.6	2.1	2.2
n <sub>3</sub>	2.1	2.1	1.6	2.3	2.3	1.7	2.1
n <sub>4</sub>	2.3	2.0	1.9	2.2	2.4	1.9	2.1
n <sub>5</sub>	2.0	1.8	1.8	2.0	2.2	2.0	1.9
Mean	2.2	2.1	1.9	2.3	2.6	1.9	
	SEm (±)		CD (0.05)				
n	0.04		0.122				
v	0.03		0.079				
n×v	0.06		0.177				
n(v <sub>i</sub> ×v <sub>j</sub> )	0.07		0.202				

\*Main plot (Nutrient levels, N)

n<sub>1</sub>- 35:26:7 kg NPK ha<sup>-1</sup>

n<sub>2</sub> -34:21:3 kg NPK ha<sup>-1</sup>

n<sub>3</sub> -34:35:3 kg NPK ha<sup>-1</sup>

n<sub>4</sub> -31:20:16 kg NPK ha<sup>-1</sup>

n<sub>5</sub> -30:15:30 kg NPK ha<sup>-1</sup>

\*Sub plot (Varieties, V)

v<sub>1</sub>- Kayamkulam 1

v<sub>2</sub>- Thilathara

v<sub>3</sub> - Thilarani

v<sub>4</sub> - Thilak

v<sub>5</sub> - GT 10

v<sub>6</sub> -TMV 7

Leachates of tested sesame varieties had significant impact on seedling growth of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*.

Leachate of variety GT 10 had significant inhibitory effect on the germination of seeds of *Alternanthera sessilis* and *Setaria barbata* and tubers of *Cyperus rotundus* resulting in the lowest number of germinated seeds/ tubers (3.33, 2.67 and 2.00, respectively) with a germination percentage of 16.65 per cent, 13.35 per cent and 10.00 per cent, respectively.

Leachate of variety GT 10 had significant inhibitory effect on the shoot length and root length of *Alternanthera sessilis* (1.10 cm and 1.46 cm, respectively), *Setaria barbata* (1.27 cm and 1.40 cm, respectively) and *Cyperus rotundus* (1.86 cm and 2.16 cm respectively).

Leachate of variety GT 10 resulted in lower seedling fresh weight in *Alternanthera sessilis* (0.20 g) which was on par with Thilarani (0.21 g), TMV 7 (0.22 g) and Thilathara (0.23 g). While, the lowest seedling fresh weight of *Setaria barbata* and *Cyperus rotundus* (0.21 g and 0.30 g, respectively) were observed with the application of leachate of variety GT 10.

Among the different sesame leachates, the lowest seedling dry weight of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus* were recorded in the leachate of variety GT 10 (0.09 g, 0.08 g and 0.11 g, respectively)

Similarly, SVI I and II were also significantly influenced by leachates of different sesame varieties. Leachate of variety GT 10 resulted in the lowest SVI I and SVI II in *Alternanthera sessilis* (42.72 and 1.83, respectively), *Setaria barbata* (35.59 and 1.07 respectively) and *Cyperus rotundus* (40.34 and 1.10, respectively).

#### **4.3.2 Assessment of Allelopathic Effect of Sesame on Selected Crops**

The allelopathic effect of leachates of sesame on the seedling growth of selected crops revealed that application of leachate of variety GT 10 resulted in the lowest number of seeds germinated and germination percentage in cowpea (1.67 and 16.70%, respectively) and okra (5.00 and 50.00%, respectively). While the germination of amaranthus was not significantly influenced by the leachates of sesame.

Leachate of variety GT 10 had strong inhibitory effect on seedling shoot length and root length of cowpea (1.20 cm and 1.75 cm respectively) and okra (2.85 cm and 1.98 cm respectively).

Leachate of variety GT 10 resulted in the lowest seedling fresh weight and dry weight of cowpea (0.23 g and 0.11 g, respectively) and okra (0.26 g and 0.06 g, respectively). However, the seedling shoot length, root length, fresh weight and dry weight of amaranthus were not significantly influenced by the leachates.

Similarly, SVI I and SVI II were significantly influenced by sesame leachates. Among the leachates, leachate of variety GT 10, produced the lowest SVI I and SVI II in cowpea (111.00 and 1.83, respectively) and okra (240.25 and 3.00, respectively). However, sesame leachates did not have any significant effect on SVI I and SVI II of amaranthus.

It could be concluded from results that the optimum nutrient level for sesame under partial shade of coconut in Southern Laterites is 34:21:3 kg NPK ha<sup>-1</sup>. The variety GT 10 was identified as the best suitable sesame variety for Southern Laterites. The variety GT 10 raised under partial shade of coconut gardens manured with 5 t ha<sup>-1</sup> of FYM + 34:21:3 kg NPK ha<sup>-1</sup> (full dose of P, K and 75 per cent N as basal application and 25 per cent N as foliar spray at 3 per cent concentration, 30 DAS) realized the highest seed yield, net return and B:C ratio. Application of leachate of variety GT 10 had significant inhibitory effect on the germination and growth of tested weeds (*Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*) and crops (cowpea and okra).

Table 77. Effect of leachates of sesame varieties on number of seeds/ tubers germinated and germination percentage, of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*

Treatments	Number of seeds /tubers germinated			Germination percentage (%)		
	AS	SB	CR	AS	SB	CR
Kayamkulam-1	13.33	12.67	9.34	66.65	63.35	46.67
Thilathara	12.00	10.86	10.00	60.00	54.30	50.00
Thilarani	14.67	12.66	8.67	73.35	63.30	43.35
Thilak	15.33	10.13	8.00	76.65	50.65	40.00
GT-10	3.33	2.67	2.00	16.65	13.35	10.00
TMV-7	7.33	6.67	6.67	36.65	33.35	33.35
Control	20.00	20.00	20.00	100.00	100.00	100.00
SEm ( $\pm$ )	0.01	0.06	0.15	4.51	4.08	4.51
CD (0.05)	0.288	0.235	0.401	13.252	11.987	13.252

Table 78. Effect of leachates of sesame varieties on seedling shoot length and root length of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*, cm

Treatments	Seedling shoot length			Seedling root length		
	AS	SB	CR	AS	SB	CR
Kayamkulam1	2.17	2.67	3.37	2.50	2.53	4.30
Thilathara	2.37	2.30	3.27	2.80	2.50	4.23
Thilarani	2.27	2.17	2.46	2.70	2.66	4.13
Thilak	2.26	2.20	2.53	2.56	2.43	4.45
GT-10	1.10	1.27	1.86	1.46	1.40	2.16
TMV-7	2.00	2.07	3.16	2.30	2.23	3.63
Control	2.67	2.80	3.83	3.10	3.10	5.77
SEm ( $\pm$ )	0.09	0.08	0.17	0.08	0.21	0.20
CD (0.05)	0.268	0.238	0.519	0.253	0.075	0.599

\*AS: *Alternanthera sessilis*, SB: *Setaria barbata*, CR: *Cyperus rotundus*

Table 79. Effect of leachates of sesame varieties on seedling fresh weight and dry weight of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*, g

Treatments	Seedling fresh weight			Seedling dry weight		
	AS	SB	CR	AS	SB	CR
Kayamkulam I	0.25	0.30	0.48	0.16	0.13	0.25
Thilathara	0.23	0.28	0.49	0.15	0.16	0.26
Thilarani	0.21	0.29	0.47	0.14	0.17	0.32
Thilak	0.26	0.32	0.48	0.19	0.15	0.29
GT-10	0.20	0.21	0.30	0.09	0.08	0.11
TMV-7	0.22	0.26	0.45	0.14	0.12	0.27
Control	0.33	0.35	0.60	0.20	0.19	0.35
SEm ( $\pm$ )	0.01	0.02	0.02	0.003	0.006	0.02
CD (0.05)	0.038	0.040	0.067	0.0172	0.0178	0.057

Table 80. Effect of leachates of sesame varieties on seedling vigour index I and II of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*

Treatments	Seedling vigour index I			Seedling vigour index II		
	AS	SB	CR	AS	SB	CR
Kayamkulam-I	311.35	329.51	357.89	10.67	8.24	11.67
Thilathara	310.20	260.78	375.00	9.00	8.69	13.00
Thilarani	364.45	306.33	285.98	10.27	10.77	13.87
Thilak	370.09	234.75	279.44	14.57	7.60	11.60
GT-10	42.72	35.59	40.34	1.83	1.07	1.10
TMV-7	157.68	143.42	226.54	5.13	3.99	8.99
Control	577.00	590.00	960.00	20.00	19.00	35.00
SEm ( $\pm$ )	13.82	19.09	35.22	0.46	0.58	1.58
CD (0.05)	40.58	56.068	103.414	1.374	1.725	4.663

\*AS: *Alternanthera sessilis*, SB: *Setaria barbata*, CR: *Cyperus rotundus*

Table 81. Effect of leachates of sesame varieties on number of seeds germinated and germination percentage of cowpea, okra and amaranthus

Treatments	Number of seeds germinated			Germination percentage (%)		
	cowpea	okra	amaranthus	cowpea	okra	amaranthus
Kayamkulam-1	6.67	8.50	10.00	66.67	85.00	100
Thilathara	6.00	7.00	10.00	60.00	70.00	100
Thilarani	7.33	6.75	10.00	73.33	67.50	100
Thilak	7.67	7.75	10.00	76.67	77.50	100
GT-10	1.67	5.00	10.00	16.70	50.00	100
TMV-7	3.67	6.25	10.00	36.67	62.50	100
Control	10.00	9.75	10.00	100.00	97.50	100
SEm ( $\pm$ )	0.11	0.13	0	3.32	4.56	0
CD (0.05)	0.221	0.280	NS	8.736	11.128	NS

Table 82. Effect of leachates of sesame varieties on seedling shoot length and root length of cowpea, okra and amaranthus, cm

Treatments	Seedling shoot length			Seedling root length		
	cowpea	okra	amaranthus	cowpea	okra	amaranthus
Kayamkulam1	2.25	4.18	2.96	2.98	3.05	1.70
Thilathara	2.48	3.85	3.04	2.70	3.23	1.89
Thilarani	2.33	5.10	2.90	2.93	2.78	1.77
Thilak	2.25	4.43	3.00	2.83	2.95	1.92
GT-10	1.20	2.85	2.95	1.75	1.98	1.99
TMV-7	2.35	5.38	2.91	2.45	2.95	1.90
Control	3.35	6.30	3.02	4.13	3.83	2.01
SEm ( $\pm$ )	0.12	0.15	0	0.14	0.16	0
CD (0.05)	0.251	0.340	NS	0.306	0.327	NS

\*NS: Non Significant

Table 83. Effect of leachates of sesame varieties on seedling fresh weight and dry weight of cowpea, okra and amaranthus, g

Treatments	Seedling fresh weight			Seedling dry weight		
	cowpea	okra	amaranthus	cowpea	okra	amaranthus
Kayamkulam1	0.32	0.51	0.23	0.18	0.18	0.11
Thilathara	0.35	0.35	0.24	0.17	0.15	0.10
Thilarani	0.34	0.34	0.26	0.16	0.13	0.11
Thilak	0.39	0.36	0.21	0.14	0.14	0.10
GT-10	0.23	0.26	0.22	0.11	0.06	0.10
TMV-7	0.40	0.51	0.25	0.15	0.18	0.10
Control	0.52	0.55	0.27	0.21	0.20	0.12
SEm ( $\pm$ )	0.02	0.02	0	0.01	0.01	0
CD (0.05)	0.032	0.031	NS	0.009	0.006	NS

Table 84. Effect of leachates of sesame varieties on seedling vigour index I and II of cowpea, okra and amaranthus

Treatments	Seedling vigour index I			Seedling vigour index II		
	cowpea	okra	amaranthus	cowpea	okra	amaranthus
Kayamkulam-1	391.25	614.50	466.00	12.00	15.30	11.00
Thilathara	453.25	495.60	493.00	10.20	10.50	10.00
Thilarani	472.50	531.50	467.00	11.73	8.78	11.00
Thilak	342.00	571.50	492.00	10.73	10.85	10.00
GT-10	111.00	240.25	494.00	1.83	3.00	10.00
TMV-7	372.75	520.50	481.00	5.50	11.22	10.00
Control	747.50	987.50	503.00	21.00	20.00	12.00
SEm ( $\pm$ )	25.10	45.08	0	0.69	0.72	0
CD (0.05)	54.211	92.174	NS	1.593	1.854	NS

\*NS: Non Significant

## **DISCUSSION**

## 5. DISCUSSION

The research work entitled “Agro-techniques for sesame (*Sesamum indicum* L.) under partial shade of coconut in Southern Laterites” was carried out to standardize the nutrient levels for sesame under partial shade of coconut in Southern Laterites, assess the response of promising sesame varieties to the identified optimum nutrient levels and evaluate the allelopathic effect of sesame on selected weeds and crops. The results of the experiments are discussed in this chapter.

### 5.1 EXPERIMENT I: STANDARDIZATION OF NUTRIENT LEVELS FOR SESAME UNDER PARTIAL SHADED COCONUT GARDENS IN SOUTHERN LATERITES

#### 5.1.1 Effect of Nutrient Levels on Growth Characters of Sesame

Crop intensification to enhance the productivity has driven massive rise in total fertilizer consumption. However, comprehensive approaches to sustainability, prioritise the importance of AEU based nutrient management practices in crops. In the present study to standardize the nutrient levels for sesame in Southern Laterites, the growth parameters of sesame *viz.*, plant height, number of leaves per plant, number of branches per plant and DMP were significantly influenced by different nutrient levels. The results on the growth parameters revealed that higher growth parameters were observed in T<sub>1</sub> (31:20:16 kg NPK ha<sup>-1</sup>), at 20 DAS, 40 DAS, 60 DAS and harvest during 2021-22 and 2022-23. Better expression of growth attributes in T<sub>1</sub> could be attributed to the balanced nutrition which might have enhanced the availability of nutrients in the rhizosphere, resulting in absorption of adequate amount of nutrients. Averbek *et al.* (2007) opined that optimum crop growth and yield was the response of availability of adequate amount of nutrients.

Arigita *et al.* (2005) observed that balanced application of NPK improved the activity of endogenous cytokinin resulting in the production of a greater number of leaves, which eventually increased the photosynthetic area. Magen (2008) observed that the growth and yield parameters in crops could be improved by supplementing appropriate proportion of N, P and K. Activity of enzymes involved in plant metabolism *viz.*, nitrate reductase, glutamine synthase, sucrose synthase

and sucrose phosphate synthase were linked with optimum crop nutrition and sink strength in crops (Sun *et al.*, 2020).

Nitrogen is an indispensable element favouring plant metabolism. Application of adequate amount of N increased the chlorophyll content, leaf area and rate of photosynthesis (Ahmed *et al.*, 2009). Being the constituent of protoplasm and chloroplast, optimum dose of N, might have stimulated the meristematic activity and enhanced the plant height in T<sub>1</sub>. Increase in nutrient availability would have led to better root and shoot development and ultimately promoted vegetative growth by aiding cell division and cell elongation attributing to greater number of leaves, branches and DMP per plant (Fig.7). Higher number of leaves and LAI (Tables 7a, 7b, 10a and 10b) might have increased the solar radiation intercepted by the crop canopy and production of photosynthates which resulted in better crop growth and DMP. Higher DMP might also be attributed to the improvement in physiological processes like cell division and differentiation and enhanced activity of growth promoters such as indole-3-acetic acid (IAA) and gibberellins (Wang and Ruan, 2013). Shilpi *et al.* (2012) revealed that the plant height (112.2 cm), number of branches per plant (11.5) and number of leaves per plant (47.6) were significantly higher in sesame manured with N at 40 kg ha<sup>-1</sup>. Nitrogen at 40 kg ha<sup>-1</sup> resulted in taller plants (151.7 cm), greater number of branches (3.8) and higher DMP per plant (12.0 g) compared to N at 20 kg ha<sup>-1</sup> in sesame (Bijarnia *et al.*, 2019).

Higher rate of N reduced the crop growth due to physiological disorders associated with excessive N uptake, dilution effect on other nutrients and soil acidification (Qiao *et al.*, 2012). This might be the plausible reason behind the lower expression of growth parameters in treatments with higher level of N in the present study. Zhao *et al.* (2014) opined that compared to higher level of N, lower levels of N sustained crop growth, yield and nutrient use efficiency in sunflower. Golan *et al.* (2022) observed that higher rate of N application resulted in reduced photosynthetic rate, stomatal conductance and leaf water potential in sesame. The

results on growth parameters confirmed the sufficiency of 31 kg N ha<sup>-1</sup> for sesame in Southern Laterites.

Phosphorus is a vital nutrient for crop growth and yield next to N. It played an important role in cell division, cell elongation, enzyme activation and carbohydrate metabolism (Razaq *et al.*, 2017). Phosphorus helps in stimulating early seed germination and root development. Better expression of growth parameters in T<sub>1</sub> might be due to the result of better root growth aiding enhanced uptake of water and nutrients by the crop. Shehu *et al.* (2010) revealed that application of P at 22.5 kg ha<sup>-1</sup> resulted in improved expression of growth attributes in sesame. Significantly taller plants, greater number of branches and leaves were noticed with the application P at 26.4 kg ha<sup>-1</sup> in sesame (Haruna *et al.*, 2010). However, excess supply of P resulted in shallow root system, inhibited the growth and development of primary root, decreased the number of meristematic cortical cells and subsequently reduced the absorption of nutrients from soil leading to stunted plant growth (Shukla *et al.*, 2017). This might have resulted in inferior growth attributes in the treatments with higher level of P. The results on growth parameters indicated that P at 20 kg ha<sup>-1</sup> was sufficient for sesame in Southern Laterites.

Potassium is one of the important nutrients required for ensuring better plant growth. It promoted cell growth by stimulating and controlling ATPase in cell membrane and subsequently triggering loosening of cell wall and hydrolase activity (Marschner, 2012). Potassium is essential for optimizing plant growth and maximizing yield by enhancing photosynthesis and assimilating carbon. It is also involved in regulation of stomata, osmotic pressure of cells and balancing ions in the cytoplasm. Bijarnia *et al.* (2019) revealed that application of K at 20 kg ha<sup>-1</sup> resulted in taller plants, greater number of branches per plant and higher DMP per plant. Kale *et al.* (2019) observed that in sesame, application of K at 20 kg ha<sup>-1</sup> resulted in taller plants and greater number of branches per plant at 60 DAS and harvest. Better expression of growth parameters in T<sub>1</sub> might be due to increase in photosynthesis, enhanced transport of photosynthates from leaves to roots and

higher nitrogen use efficiency. The results represented the sufficiency of 16 kg K ha<sup>-1</sup> for sesame in Southern Laterites. It was in accordance with the observations of Xu *et al.* (2020) who observed that optimal supply of K enhanced crop growth by improving the rate of photosynthesis, transport of assimilates from source to sink and enhancing the activities of C and N metabolizing enzymes. Conclusively the balanced application of NPK stimulated the overall growth of sesame.

### **5.1.2 Effect of NPK on Physiological Parameters of Sesame**

Leaf area index of sesame was significantly influenced by nutrient levels. Among the different nutrient levels, T<sub>1</sub> (31:20:16 kg NPK ha<sup>-1</sup>) resulted in higher LAI at all stages of growth, during both years. Leaf area index was maximum at 60 DAS (Fig.8) due to the presence of greater number of leaves, which decreased afterwards due to leaf senescence. Higher LAI noted in T<sub>1</sub>, was due to the presence of more number of leaves per plant (Tables 7a and 7b), which indicated efficient utilization of nutrients by the crop. Better availability and uptake of nutrients and its translocation to the growing points contributed enhanced growth. Higher LAI would have improved the plant's ability to intercept sunlight, leading to efficient photosynthesis and assimilate production. Moreover, better nutritional environment might have stimulated the vegetative growth by promoting cell multiplication, cell division and cell elongation, amino acid synthesis and energy transformation. Eifediyi *et al.* (2017), observed that application of 20:10:10 kg NPK ha<sup>-1</sup> in sesame resulted in higher leaf area at 4 weeks after planting (WAP), 6 WAP and 8 WAP (38.1 cm<sup>2</sup>, 46.1 cm<sup>2</sup> and 51.7 cm<sup>2</sup>, respectively). Umar *et al.* (2012) revealed that N applied at 40 kg ha<sup>-1</sup> resulted in higher LAI (3.4) compared to N @ 20 kg ha<sup>-1</sup> (3.2) in sesame.

Chlorophyll is a vital pigment involved in capturing light energy and its content in leaves is closely related to the photosynthetic capacity of the plants. The results revealed that higher chlorophyll content was observed in T<sub>1</sub>. Significant impact of nutrients on the formation of chlorophyll was reported by Amujoyegbe *et al.* (2007). The photosynthetic activity of the plant is based on the quantity of pigments in the chloroplast that is directly proportional to the photosynthetic area.

Higher LAI and greater number of leaves in T<sub>1</sub> might have contributed to better assimilation of nutrients and increased chlorophyll content. Zhang *et al.*, (2019) observed that different leaf characteristics *viz.*, number of leaves per plant and leaf area played significant role in enhancing the chlorophyll content of the leaves. Increased chlorophyll content in T<sub>1</sub> might also be due to the direct effect of nutrients on the photochemical activity of the plant. Nitrogen is the structural constituent of chlorophyll. Higher N assimilation in the leaves would have enabled the production of greater number of chlorophyll pigments. Low rate of photosynthesis under limited supply of N is often ascribed to decreased chlorophyll content in leaves (Toth *et al.*, 2002). Similarly, application of P within certain limits was positively correlated with the chlorophyll content of leaves, since chlorophyll is an integral part of plant cells involved in photosynthesis and respiration (Prsa *et al.*, 2007). The increase in chlorophyll content in response to supply of phosphate fertilizer was also due to the greater absorption of N by the crop in the presence of P (Shubhra *et al.*, 2004). Similarly, application of adequate amount of K also increased the formation of chlorophyll by increasing the activity of chlorophyll oxygenase enzyme and expression of CAO1 gene involved in chlorophyll synthesis (Biswal *et al.*, 2012). Prasad and Srivastav (2020) revealed that application of 40:20:20 kg NPK ha<sup>-1</sup> + FYM @ 2.5 t ha<sup>-1</sup> increased the LAI and chlorophyll content at 60 DAS in sesame (2.4 and 65.6 %, respectively).

Crop growth rate and relative growth rate are the key metrics used in growth analysis to understand the dynamics of plant growth and productivity. Crop growth rate measures the increase in dry matter of a crop over time. The results revealed that higher CGR were observed at T<sub>1</sub> at all stages of observation. Adequate and balanced application of NPK helped in promoting the growth parameters of the plant which resulted in higher DMP. Higher CGR observed in T<sub>1</sub> was due to higher biomass production resulting from more number of leaves, leaf area and branches per plant. Cirilo *et al.* (2009) opined that CGR is depended on the radiation use efficiency, which represented the amount of intercepted photosynthetic active radiation (PAR) and efficiency of the crop to convert PAR to above ground

biomass. Better photosynthesis and carbohydrate accumulation due to larger leaf area might have resulted in higher CGR in T<sub>1</sub>. However, the CGR decreased at later stages of crop growth, attributing to various physiological processes including senescence, reduction in the number of leaves, leaf area index and redistribution of nutrients and carbohydrates from vegetative parts to reproductive structures.

Relative growth rate represents the relative increase in plant biomass per unit of existing biomass. Higher RGR was observed in T<sub>1</sub> at 20 DAS-40 DAS and 40 DAS-60 DAS. It might be attributed to higher dry matter accumulation (Tables 9a and 9b) and uptake and translocation of nutrients to reproductive plant parts. Relative growth rate was higher at early stages and showed a decreasing trend towards the maturity of the crop. As the plant approaches physiological maturity, the demand for photo assimilates might be redirected from new tissues to the maintenance of existing tissues (Benincasa, 2003). The decrease in RGR was due to the increase in metabolically active tissues and decrease in meristematic tissues which resulted in reduced growth at later stages of the crop (Hussain *et al.*, 2011). Verma *et al.* (2013) opined that application of 30:20:10 kg NPK ha<sup>-1</sup> resulted in higher CGR and RGR at 30 DAS-60 DAS and 60 DAS-90 DAS in sesame (4.6 g m<sup>-2</sup> d<sup>-1</sup> and 12.4 mg g<sup>-1</sup> d<sup>-1</sup>, respectively and 5.0 g m<sup>-2</sup> d<sup>-1</sup> and 7.13 mg g<sup>-1</sup> d<sup>-1</sup>, respectively).

### **5.1.3 Effect of Nutrient Levels on Yield Attributes and Yield of Sesame**

The results presented in Tables 14, 15, 16 and 17 showed that the nutrient levels had significant influence on yield attributes and yield of sesame during both years.

The capsules per plant, seeds per capsule, seed yield per plant, seed yield ha<sup>-1</sup>, haulm yield per plant, haulm yield per ha<sup>-1</sup> and harvest index were higher in T<sub>1</sub>. However, seeds per capsule, haulm yield per plant, haulm yield per ha<sup>-1</sup> and harvest index were on par with T<sub>2</sub>. Balanced application of NPK might have augmented the yield attributes of sesame in T<sub>1</sub>. Better yield attributes realized with the application of 31:20:16 kg NPK ha<sup>-1</sup> was the manifestation of efficient

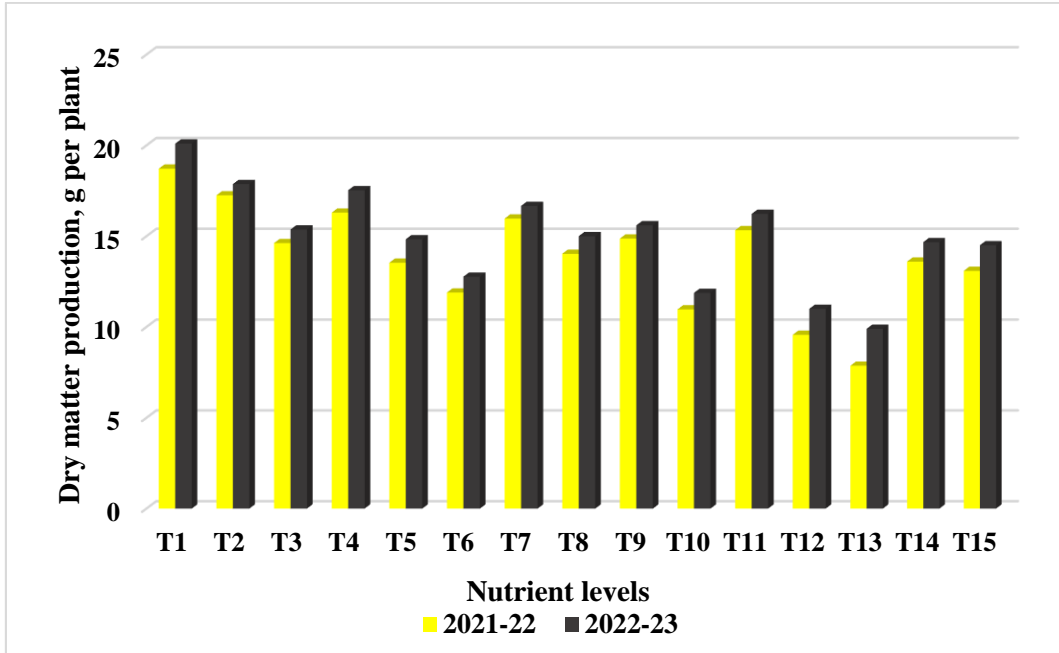


Fig 7. Effect of nutrient levels on DMP at harvest during 2021-22 and 2022-23

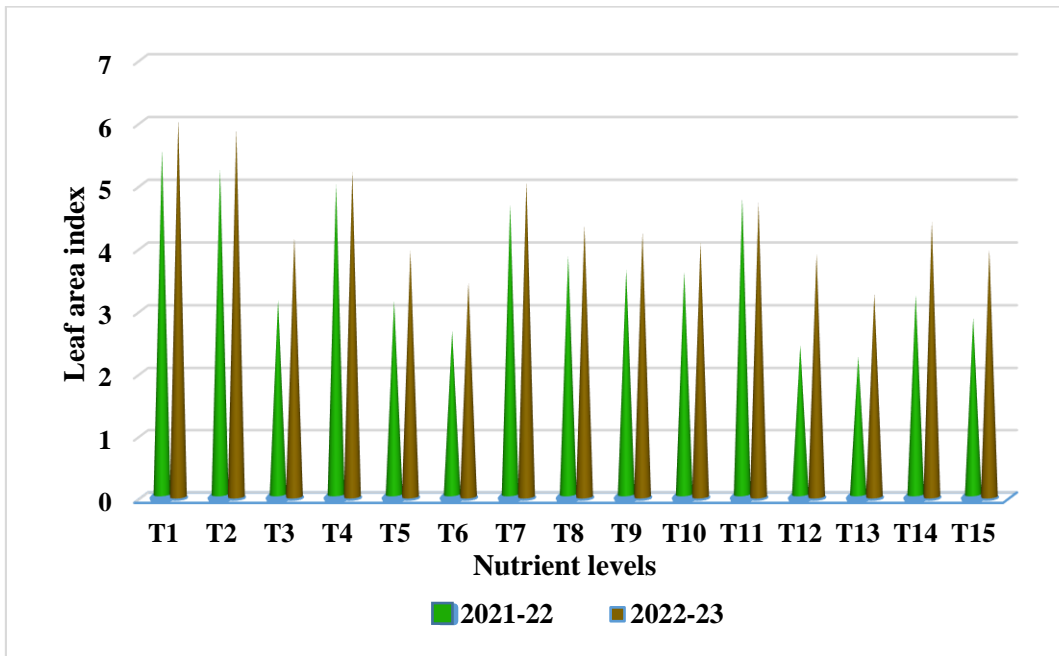


Fig. 8. Effect of nutrient levels on LAI at 60 DAS during 2021-22 and 2022-23

vegetative system as evidenced from taller plants, greater number of leaves and branches per plant, higher DMP and LAI. Supplementing essential nutrients (NPK) in optimal quantity resulted in better translocation of assimilates, increased flower formation, reduced flower drop, improved pollination, fertilization and capsule set, which ultimately led to higher yield in crops (Kaushik and Dijwanti, 2017). Increased uptake of nutrients from the soil (Tables 32, 33, 34, 35, 36 and 37) would have provided enough carbohydrates in the leaves for efficient translocation to the sink, favouring enhanced seed yield. Higher LAI, number of capsules per plant and seeds per capsule evinced in T<sub>1</sub> indicated better source-sink balance. Higher uptake of nutrients, ensuing photosynthetic efficiency and source-sink relation led to better expression of yield attributes and yield in sesame. Optimum supply of nutrients had significant effect in regulating the translocation of photosynthates from source to sink (Zhao *et al.*, 2019). Sharongmangyang and Nongmaithem (2019) observed that application of 40:20:20 kg NPK ha<sup>-1</sup> resulted in greater number of capsules per plant (62), seeds per capsule (29), higher seed yield (332 kg ha<sup>-1</sup>) and haulm yield (1760 kg ha<sup>-1</sup>) compared to control in sesame.

Nitrogen is an inevitable nutrient required for both vegetative and reproductive growth of the plant, as it is the major structural constituent of cells. The yield attributes which decide the crop yield is the function of the vegetative build-up of crop and partitioning of photosynthates in the crop. Better crop growth in T<sub>1</sub> was evident from higher LAI and DMP which consequently resulted in higher rate of photosynthesis and assimilate production. The seed yield is a function of yield attributes *viz.*, number of capsules per plant and seeds per capsule. The translocation of assimilates from source to sink, might have led to the production of greater number of capsules per plant (Table 14 and Fig.9) and seeds per capsule (Table 15 and Fig. 10). Thus, better expression of these attributes might have led to higher seed yield in T<sub>1</sub> (Table 17 and Fig.11 and Fig.12). Shilpi *et al.* (2012) observed that application of N at 40 kg ha<sup>-1</sup> resulted in greater number of capsules per plant (64.2), seeds per capsule (47.7), higher seed yield (1310.0 kg ha<sup>-1</sup>) and haulm yield (3050.0 kg ha<sup>-1</sup>) compared to N at 60 and 100 kg ha<sup>-1</sup>. Shweta *et al.*

(2023) reported that application of N at 30 kg ha<sup>-1</sup> enhanced the activity of CO<sub>2</sub> fixing enzymes, rate of photosynthesis, dry matter accumulation and partitioning of assimilates to sink, ultimately leading to higher seed yield in sesame.

Phosphorus fertilization also had significant effect on yield improvement in sesame. Adequate supply of P helped in maintaining better source-sink relationship by increasing the sink capacity due to its role in energy transformation. Phosphorus had an important role in root development and also played a critical role in improving the availability of nutrients to the crop. It also aids in photosynthesis and utilization of carbohydrates efficiently leading to higher seed yield. This was in accordance with the results of Deepthi *et al.* (2018) who observed that the yield attributes of sesame *viz.*, number of capsules per plant (35.7) and seeds per capsule (59) were significantly higher with the application of P at 25 kg ha<sup>-1</sup>. Younis *et al.* (2020), revealed that application of P at 25 kg ha<sup>-1</sup> resulted in more number of capsules per plant (61), higher seed yield (1381 kg ha<sup>-1</sup>), biological yield (6559 kg ha<sup>-1</sup>) and harvest index (0.2) compared to control in sesame.

The effect of K on yield attributes might be due to its pronounced role in carbohydrate synthesis, metabolism, transportation and storage of carbohydrates from source to sink (Wang *et al.*, 2013). Potassium also played a pivotal role in the translocation of water, nutrients and carbohydrates within the plant and production of protein, starch and ATP which regulated photosynthesis (Zorb *et al.*, 2014). The results were in line with Dasmahapatra *et al.* (1990) and Mandel *et al.* (1993) in sesame. Jadav *et al.* (2010) also revealed that application of 20 kg K ha<sup>-1</sup> resulted in greater number of capsules per plant (38.5), seeds per capsule (55.6), higher seed yield (537.0 kg ha<sup>-1</sup>) and haulm yield (901.0 kg ha<sup>-1</sup>) in sesame.

A substantial increase in haulm yield was observed in T<sub>1</sub>. Higher haulm yield observed in T<sub>1</sub> could be attributed to increased DMP as a result of better expression of growth and yield attributes. Better root proliferation resulted from application of adequate quantity of nutrients in the rhizosphere might have improved the nutrient uptake, consequently resulting in higher haulm yield.

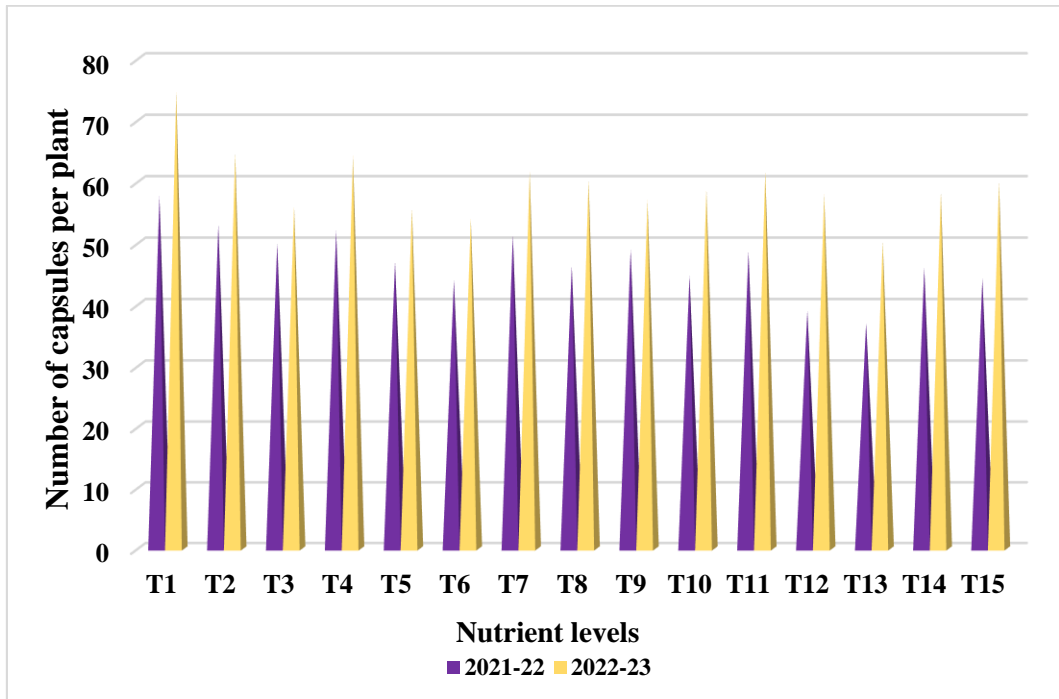


Fig. 9. Effect of nutrient levels on number of capsules per plant during 2021-22 and 2022-23

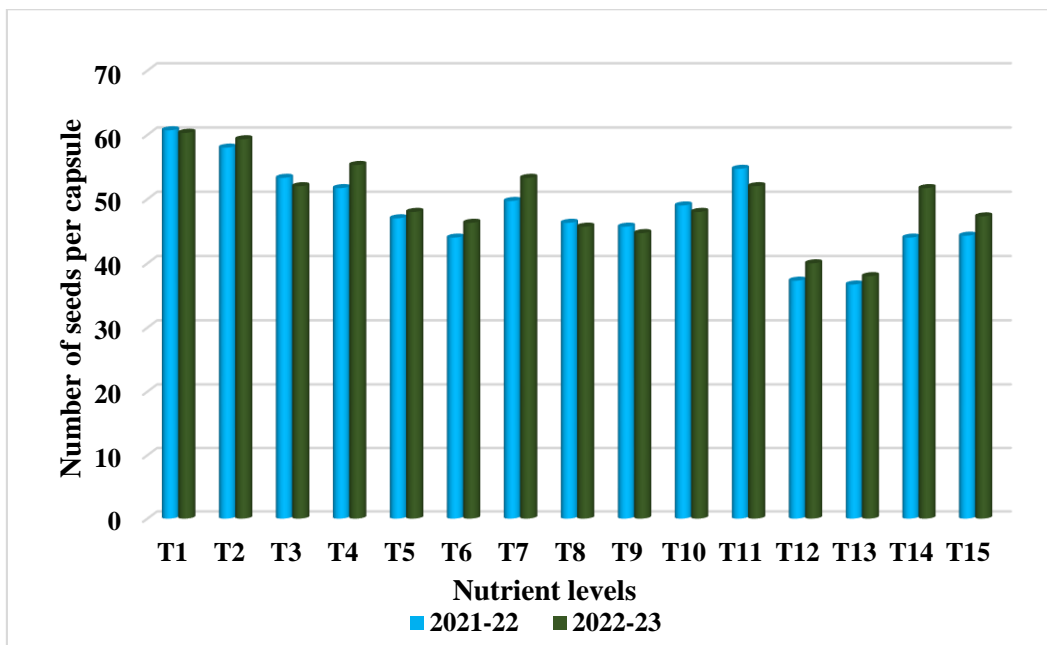


Fig. 10. Effect of nutrient levels on number of seeds per capsule during 2021-22 and 2022-23

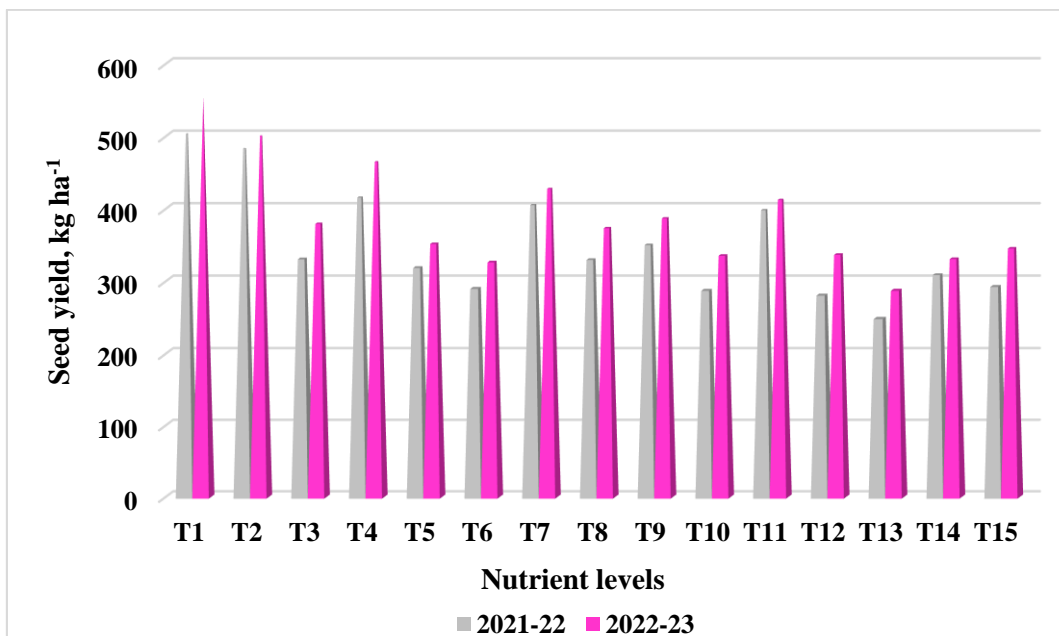


Fig.11. Effect of nutrient levels on seed yield ha<sup>-1</sup> during 2021-22 and 2022-23

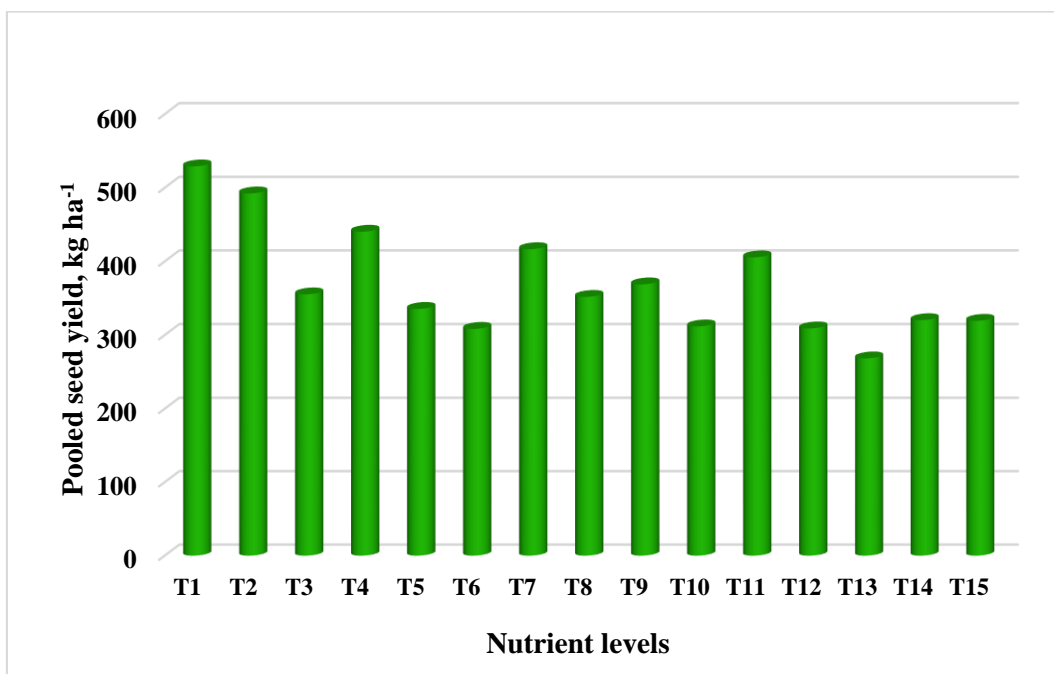


Fig 12. Effect of nutrient levels on pooled seed yield ha<sup>-1</sup>



Plate 9. Best treatment during 2021-22 ( $T_1$ : 31:20:16 kg NPK ha<sup>-1</sup>)



Plate 10. Best treatment during 2022-23 ( $T_1$ : 31:20:16 kg NPK ha<sup>-1</sup>)

Similarly, higher seed yield in T<sub>1</sub> resulted in higher HI in T<sub>1</sub> compared to other treatments. Increased HI indicated better partitioning of assimilates from source to sink. Better nutrient availability and uptake might have enhanced the photosynthesis and translocation of photosynthates from source to sink leading to higher DMP, greater number of capsules per plant and seed yield. Cumulative effect of all these factors might have contributed to higher HI in T<sub>1</sub>. Tripathy and Bastia (2012) observed that application of 30:7:12 kg NPK ha<sup>-1</sup> + FYM 5 t ha<sup>-1</sup> resulted in the greatest number of capsules per plant (59), seeds per capsule (63), higher seed yield (874 kg ha<sup>-1</sup>), haulm yield (2470 kg ha<sup>-1</sup>) and HI (0.26) in sesame. Sahu *et al.* (2024) revealed that application of 30:15:15 kg NPK ha<sup>-1</sup> resulted in the greatest number of capsules per plant (37.6), seeds per capsule (48.1), higher seed yield (591.9 kg ha<sup>-1</sup>), haulm yield (1786.7 kg ha<sup>-1</sup>) and HI (0.24) in sesame.

Three optimum N, P and K doses were obtained from CCD for higher seed yield in sesame. The contour plot for yield maximization during 2021-22 are presented in Fig. 13, 14 and 15. Figure 13 is the contour plot for yield maximization with P and K, keeping N value at a constant level of 35 kg ha<sup>-1</sup> and 34 kg ha<sup>-1</sup>. The contour plot for N and K, keeping P value at a constant level of 26 kg ha<sup>-1</sup> and 21 kg ha<sup>-1</sup> is presented in Fig.14. Similarly, the contour plot for N and P, keeping K at a constant level of 7 kg ha<sup>-1</sup> and 3 kg ha<sup>-1</sup> is depicted in Fig. 15. All the contour plots showed that the seed yield was maximum beyond 500 kg ha<sup>-1</sup>. The results revealed that the optimum NPK dose for sesame to obtain maximum seed yield beyond 500 kg ha<sup>-1</sup> were 35:26:7 kg ha<sup>-1</sup> and 34:21:3 kg ha<sup>-1</sup>.

Similarly, the contour plot for yield maximization during 2022-23 are presented in Fig. 16, 17 and 18. Figure 16 is the contour plot for yield maximization with P and K, keeping N value at a constant level of 34 kg ha<sup>-1</sup>. The contour plot for N and K, keeping P value at a constant level of 35 kg ha<sup>-1</sup> is depicted in Fig.17. Similarly, the contour plot for N and P, keeping K at a constant level of 3 kg ha<sup>-1</sup> is presented in Fig.18. All the contour plots showed that the seed yield was maximum beyond 600 kg ha<sup>-1</sup>. The results revealed that the optimum NPK dose for sesame to obtain maximum seed yield beyond 600 kg ha<sup>-1</sup> was 34:35:3 kg ha<sup>-1</sup>. These results

were validated in experiment II to find the best NPK dose for sesame in Southern Laterites.

#### **5.1.4 Effect of Nutrient Levels on Quality Parameters of Sesame**

Results on quality parameters indicated that the oil, crude protein, P, Ca, Mg, Fe and Zn content in the seeds were significantly influenced by nutrient levels.

The oil content of sesame was significantly influenced by the nutrient levels only during 2021-22 and the highest oil content was observed in T<sub>1</sub> (42.1%). Improved quality parameters was an indication of better uptake of nutrients resulted from the application of adequate amount of nutrients. Significant increase in oil content in T<sub>1</sub> might be due to enhanced availability of nutrients (Tables 36 and 37) and better proliferation of roots which helped in efficient utilization and translocation of nutrients to plant parts. Application of adequate amount of nutrients would also enhance the lipid metabolism leading to higher oil content. Balanced supply of nutrients resulted in the production of more carbohydrates, which were degraded to acetyl coenzyme-A for the synthesis of fatty acid (Tripathi *et al.*, 2013). Higher uptake of nutrients might have boosted the synthesis of essential metabolites involved in the production of oil (Ola *et al.*, 2013). The accumulation of oil in sesame seeds was significantly influenced by the availability of essential nutrients (N, P and K) at the critical stages of crop growth (pod development stage) (Kaluzewicz *et al.*, 2017). However, higher dose of nutrients especially N might have resulted in reduced oil content due to the accumulation of higher amount of N and conversion of lipids to proteins in the seeds (Bellaloui *et al.*, 2018). Tripathy and Bastia (2012) observed that application of 30:6.6:12 kg NPK ha<sup>-1</sup> + FYM 5t ha<sup>-1</sup> resulted in the highest oil yield in sesame (437 kg ha<sup>-1</sup>). Priya *et al.* (2022) revealed that application of 40:20:20 kg NPK ha<sup>-1</sup> resulted in higher oil content (52.0%) in sesame compared to control (51.3%).

The results on crude protein content revealed that the treatment T<sub>1</sub> resulted in the highest crude protein content during 2021-22 and 2022-23 (Fig. 19). Adequate N application had great impact on the quality of sesame seeds. Couch *et al.* (2017) revealed that 31 to 66 per cent of N absorbed by the plant was remobilized to

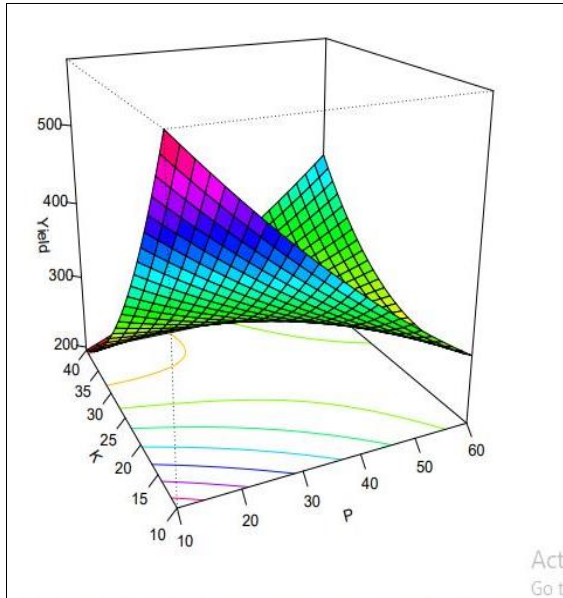


Fig. 13. Response curve for N during 2021-22

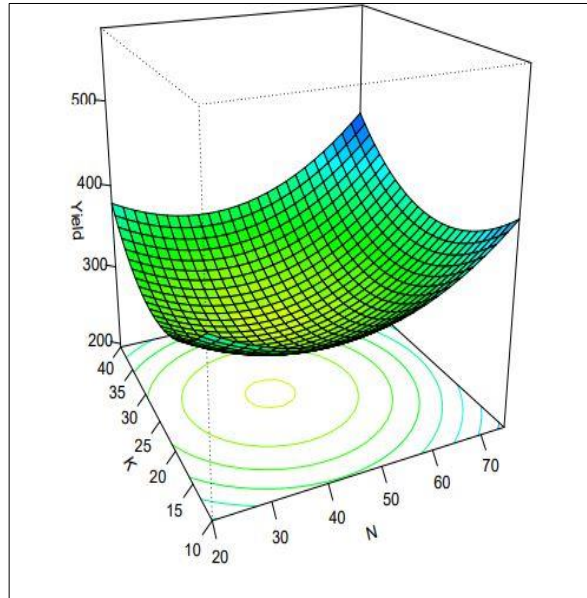


Fig. 14. Response curve for P during 2021-22

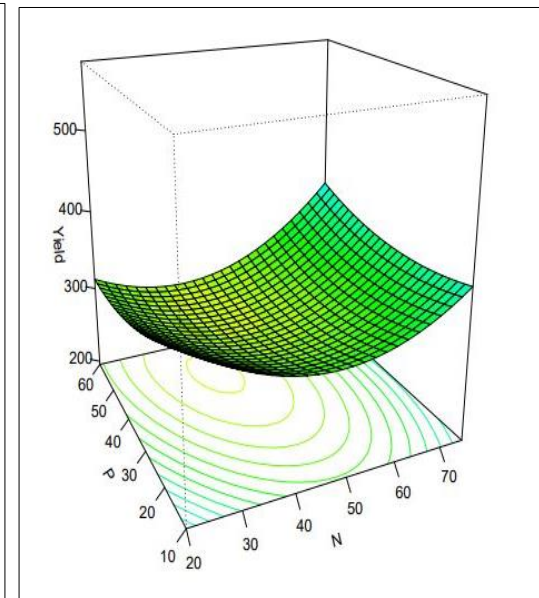


Fig. 15. Response curve for K during 2021-22



Fig. 16. Response curve for N during 2022-23

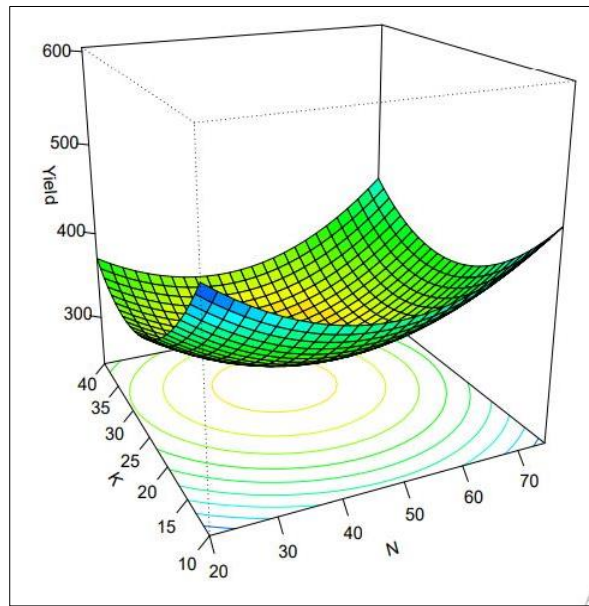


Fig. 17. Response curve for P during 2022-23

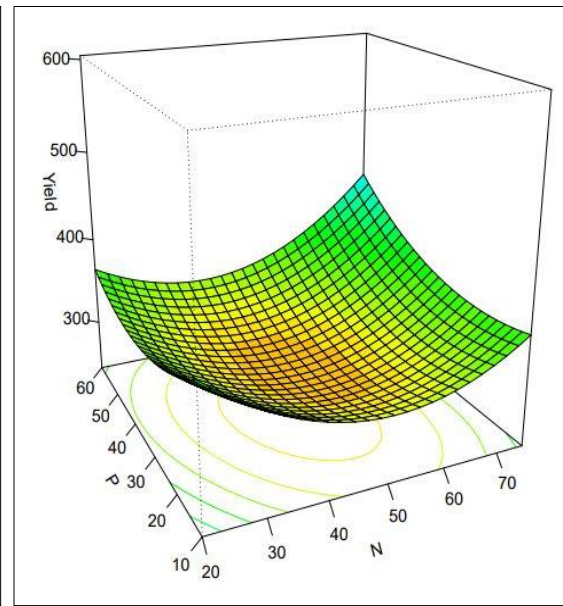


Fig. 18. Response curve for K during 2022-23

capsules and seeds. Nitrogen is an integral part of protein and P is the structural element of co-enzymes involved in protein synthesis. Protein content is positively influenced by higher N content as evinced from the uptake values (Tables 30 and 31). Better supply of nutrients might have helped in better absorption and utilization of nutrients resulting in diversion of large amount of photosynthates for protein synthesis (Sharma and Sharma, 2014). Shehu *et al.* (2010) revealed that application of 37.5:22.5:22.5 kg NPK ha<sup>-1</sup> resulted in higher crude protein content (20.1%) in sesame compared to control. Thanki *et al.* (2014) observed that application of 50:50:25 kg NPK ha<sup>-1</sup> resulted in significantly higher protein (27.1%) and oil content (51.9%) in sesame. Shakeri *et al.* (2016) observed that application N at 25 kg ha<sup>-1</sup> increased the oil content in sesame. It was also observed that N at 25 kg ha<sup>-1</sup> significantly reduced the concentration of saturated fatty acids like palmitic and stearic acid and increased the unsaturated fatty acids like oleic and linoleic acid, improving the quality of oil.

The results on quality parameters revealed that T<sub>2</sub> (64:20:16 kg ha<sup>-1</sup>) resulted in higher P content of the seeds which was on par with T<sub>1</sub> during both years. An increase in the crude protein content and P content of the seeds suggested synergistic interaction between N and P resulting in higher nutrient accumulation in the seeds of sesame (Aulakh and Malhi, 2005). Patel *et al.* (2014) observed that application of N at 25 kg ha<sup>-1</sup> resulted in higher P content in seeds of sesame (0.41%).

The Ca content in the seeds were found to be higher in T<sub>1</sub> which was on par with T<sub>2</sub>. Results also revealed that the Mg content was higher in T<sub>2</sub> which was on par with T<sub>1</sub> during 2021-22. While, during 2022-23 higher Mg content was observed in T<sub>2</sub> which was on par with T<sub>1</sub> and T<sub>4</sub> (64:50:16 kg NPK ha<sup>-1</sup>). Akande *et al.* (2011) observed that application of 16:16:16 kg NPK ha<sup>-1</sup> resulted in higher Ca (0.14%) and Mg content (0.03%) in sesame compared to control. However, T<sub>2</sub> resulted in higher Fe content which was on par with T<sub>1</sub> during both years. The results on Zn content revealed that T<sub>1</sub> resulted in higher Zn content which was on par with T<sub>2</sub> and T<sub>4</sub> during 2021-22. Higher availability and uptake of nutrients might

have resulted in improved quality parameters in the seeds. Adequate availability of N could increase the absorption of micronutrients in plant tissues. Application of N had positive interactions with the accumulation of P, Ca, Mg, Zn and Fe (Fageria *et al.*, 2015). However, excess application of P reduced the uptake of Zn which might have reduced the Zn content in the seeds due to the antagonistic interaction between P and Zn (Mousavi, 2011). Rietra *et al.*, (2017) opined that the overall increase in the micronutrient content in the seeds of sesame with the application of adequate quantity of macronutrients (N and P) was the reflection of synergistic effect of macronutrients on micronutrients. Jose *et al.* (2022) observed that application of 50:25:30 kg NPK ha<sup>-1</sup> resulted in higher P, Fe and Zn content in the sesame seeds.

#### **5.1.4 Effect of Nutrient Levels on Nutrient Uptake by Sesame**

Nutrient levels markedly influenced the N, P and K uptake by sesame during 2021-22 and 2022-23 (Fig. 20, 21 and 22). Uptake of nutrients depends on the nutrient availability and the ability of the plants to absorb the nutrients through the root system. Nutrient uptake by crop is a function of nutrient content and the DMP. However, the nutrient content in dry matter is directly related to the photosynthetic activity of leaves. It is the concentration of essential nutrients in dry weight of the plant. Jat and Gerard (2014) stated that there was a linear relationship between nutrients absorbed by the crop and economic produce.

Results revealed that higher N, P and K uptake were observed in T<sub>1</sub> (31:20:16 kg NPK ha<sup>-1</sup>) during both years. Nutrient uptake is determined by the physiological needs of the plant. Better plant growth observed in T<sub>1</sub> had resulted in improved nutrient absorption and higher biomass production that favored higher nutrient uptake and better yield. It is also interpreted that the balanced nutrition in the rhizosphere augmented the microflora and rhizosphere microbial activity that created a conducive environment for better nutrient uptake. Thepbandit and Athinuwat (2024) revealed that rhizosphere microorganisms increased the availability of nutrients by the decomposition of organic and inorganic substances present in the root zone and thus encouraged the crop

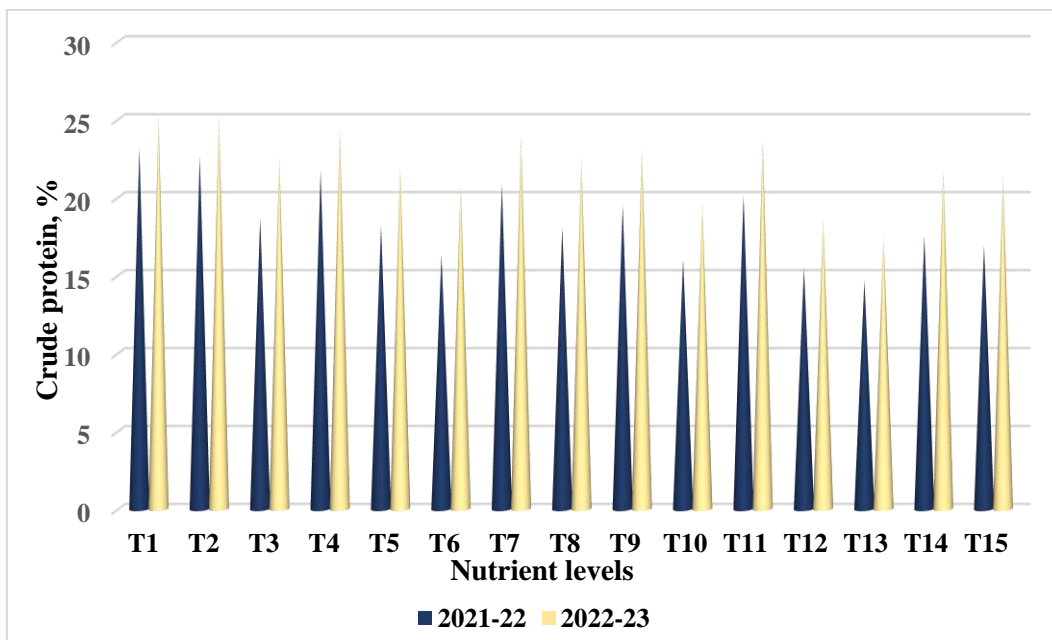


Fig.19. Effect of nutrient levels on crude protein content during 2021-22 and 2022-23

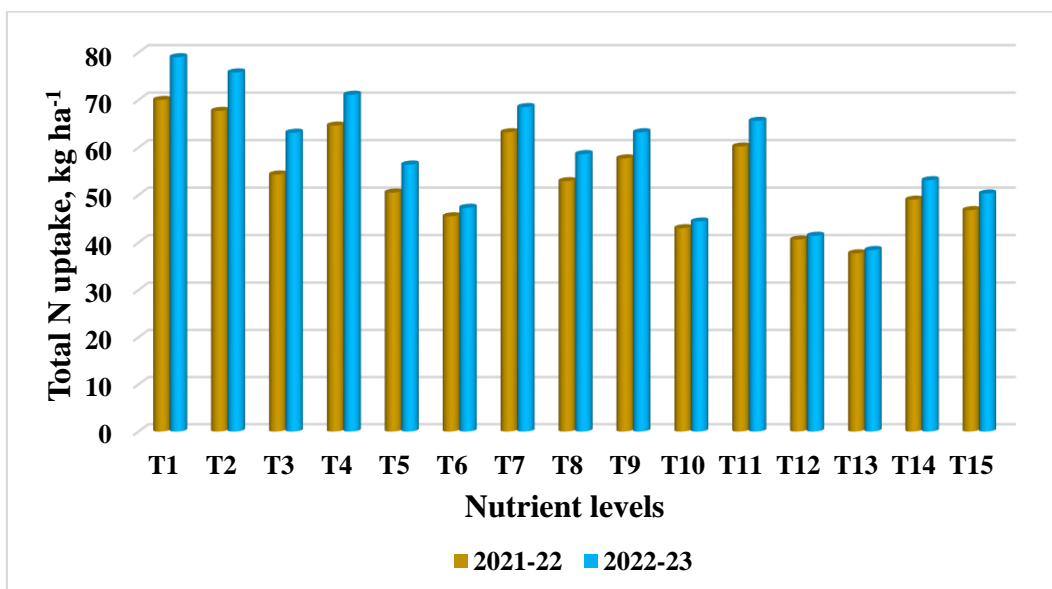


Fig. 20. Effect of nutrient levels on total N uptake during 2021-22 and 2022-23

growth. The increased availability of nutrients in the root zone coupled with metabolic activity at cellular level might have augmented the nutrient uptake. Higher nutrient uptake could also be attributed to the additive effect of higher seed yield, haulm yield and nutrient content in seed and haulm. Murthy *et al.* (2015) observed that adequate supply of nutrients increased the nutrient availability in soil solution eventually resulting in higher nutrient uptake by plants. Li *et al.* (2019) opined that application of NPK at appropriate ratio could significantly enhance the nutrient uptake by the crop.

Balanced nutrient application resulted in synergetic effect of one nutrient on other favoring better availability of nutrients to the plant, eventually resulting in enhanced nutrient uptake. Lopez *et al.* (2023) reported that application of adequate amount of N promotes P uptake by improving the growth of tap root, increasing the plant metabolism and enhancing the P solubility and availability. Elayaraja (2015) observed that application of NPK at 35:23:23 kg ha<sup>-1</sup> resulted in higher N uptake by seed and haulm (915 and 744 mg per pot, respectively), P uptake by seed and haulm (167 and 219 mg per pot, respectively) and K uptake by seed and haulm (379 and 776 mg per pot, respectively) in sesame. Parmar *et al.* (2020) observed higher uptake of N by seed (26.0 kg N ha<sup>-1</sup>) and haulm (24.9 kg N ha<sup>-1</sup>), P uptake by seed (6.0 kg P ha<sup>-1</sup>) and haulm (11.1 kg P ha<sup>-1</sup>) and K uptake by seed (5.8 kg K ha<sup>-1</sup>) and haulm (20.3 kg K ha<sup>-1</sup>) with the application of 25:12.5 kg NP ha<sup>-1</sup> in sesame.

However, excess application of nutrients may reduce the nutrient uptake. Akintoye *et al.* (1999) reported that, increasing the nutrient levels significantly decreased the nutrient use efficiency and nutrient uptake in sesame, resulting in poor crop performance. Therefore, application of adequate amount of nutrients is very important for enhancing the nutrient uptake by the crop and yield.

#### **5.1.5 Effect of Nutrient Levels on Organic Carbon Content in the Soil and Nutrient Availability**

The post experimental soil analysis revealed that nutrient levels significantly influenced the available nutrient status of the soil, during both years.

Among the different nutrient levels, the highest organic carbon content was observed in T<sub>1</sub> (31:20:16 kg NPK ha<sup>-1</sup>) during both years. This might be attributed to the addition of organic matter to the soil, resulting from decay of leaves that shed towards the maturity of the crop. Lynch and Whips (1990) revealed that 40 per cent of dry matter accumulation by the plant was released into the rhizosphere as soil organic carbon. Balanced application of fertilizers improved the photosynthetic C uptake by plants and thus increased the biomass production (Liang *et al.*, 2014). Concurrently, it directly improved the nutrient availability in soil by better rhizosphere activity through root exudation of organic compounds which ultimately resulted in better crop growth (Zhu *et al.*, 2016). Better rhizosphere activity improved the microbial metabolism in the soil and subsequently results in higher organic carbon content in soil. Fontaine *et al.* (2011) reported that microorganisms utilized the root exudates as energy source and decomposed organic matter into more stable organic compounds which resulted in increased soil organic carbon (SOC). Qiu *et al.* (2016) demonstrated that application of appropriate quantity of N maintained the soil fertility, as N could enhance the mineralization process of soil organic carbon. In addition, it could enhance the input of carbon sources, such as crop residues and root exudates, eventually increasing the organic carbon content in the soil. Dai *et al.* (2019) opined that balanced application of nutrients were beneficial for both microbial populations and plants and consequently resulted in higher organic carbon accumulation in soil. However, Hu *et al.* (2022) opined that excessive application of fertilizers might have decomposed the organic matter present in the soil by altering the C:N ratio.

Similar to organic carbon, available N, P and K status of the soil were significantly influenced by nutrient levels. During 2021-22, higher available N was observed in T<sub>1</sub> (31:20:16 kg NPK ha<sup>-1</sup>), which was on par with T<sub>2</sub> (64:20:16 kg NPK ha<sup>-1</sup>). While, the highest available N was observed in T<sub>1</sub> during 2022-23. However the highest available P and K were observed in T<sub>1</sub> during 2021-22. While during 2022-23, available P was higher in T<sub>1</sub> and on par with T<sub>2</sub>, whereas, available K was higher in T<sub>2</sub> and was on par with T<sub>1</sub>. The increased availability of nutrients

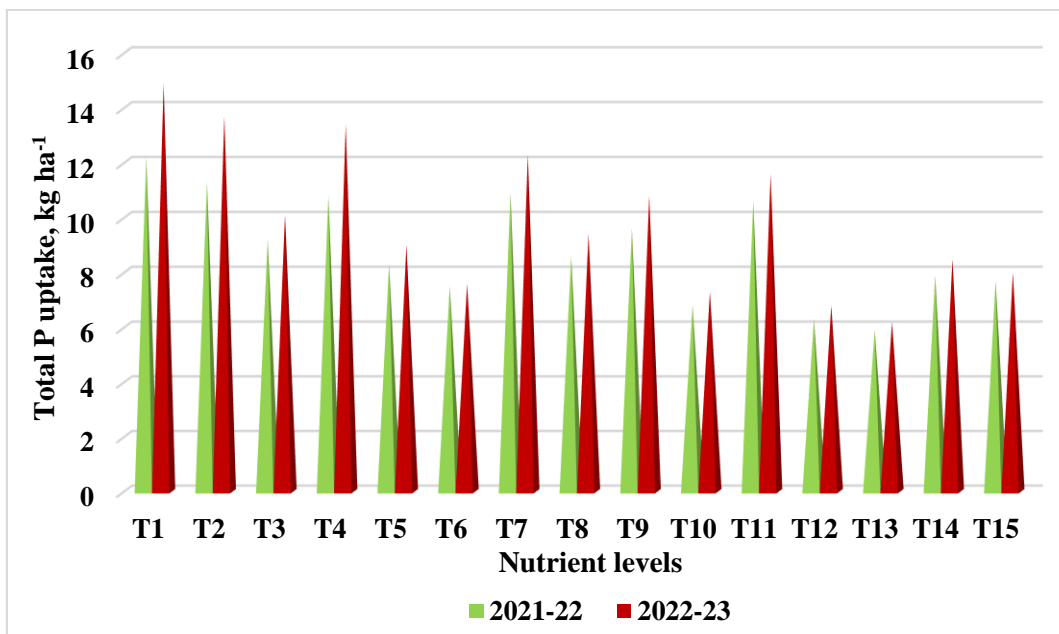


Fig. 21. Effect of nutrient levels on total P uptake during 2021-22 and 2022-23

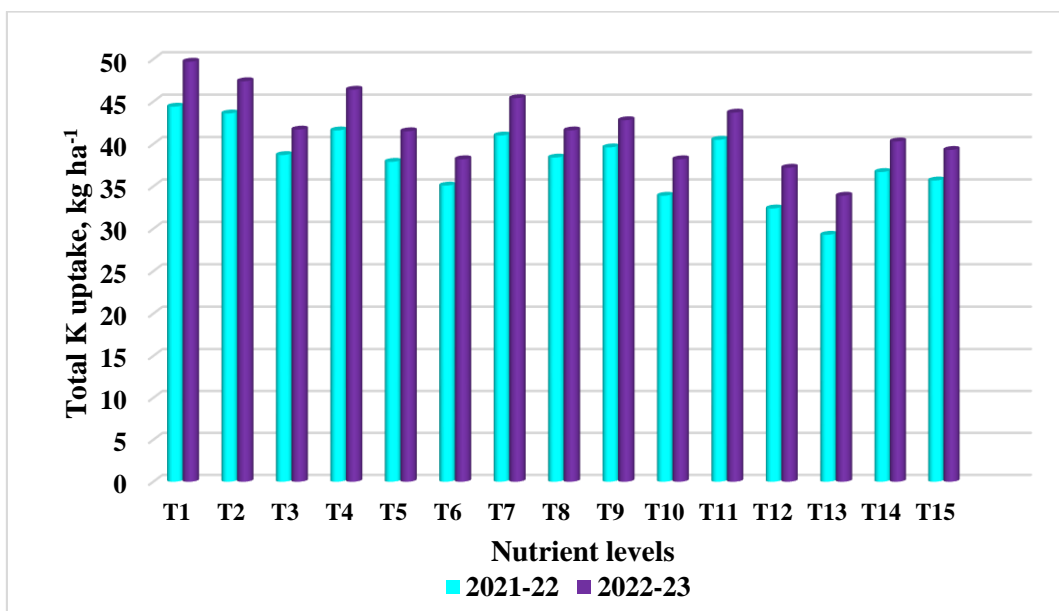


Fig. 22. Effect of nutrient levels on total K uptake during 2021-22 and 2022-23

in the soil could be attributed to the balanced application of nutrients. The nutrient dynamics in the soil, such as nutrient fixation, availability and uptake were positively correlated to the organic carbon content in the soil. Higher organic carbon in T<sub>1</sub> (Tables 36 and 37) might have influenced the availability of N, P and K by promoting mineralisation and releasing nutrients from fixed and non-exchangeable forms. Ullah *et al.* (2023) opined that higher organic carbon content in the soil enhanced the nutrient availability by preventing the nutrient loss due to leaching and erosion. Sakin (2012) observed that SOC serves as a reservoir for N, thereby increasing the availability of N in the soil. Javia *et al.* (2010) revealed that application of 25: 25 kg NP ha<sup>-1</sup> in sesame improved the SOC content (0.3 %), available P (27.1 kg ha<sup>-1</sup>) and K (217.0 kg ha<sup>-1</sup>). Similarly, Kumara *et al.* (2014) observed that application of 40:25:25 kg NPK ha<sup>-1</sup> in sesame recorded higher available N, P and K in soil (233.0 kg ha<sup>-1</sup>, 25.5 kg ha<sup>-1</sup> and 264.0 kg ha<sup>-1</sup>, respectively).

#### **5.1.6 Effect of nutrient levels on economics of cultivation**

Results revealed that, T<sub>1</sub> resulted in the highest gross return, net return and B:C ratio during 2021-22 and 2022-23.

Higher return and B:C ratio could be attributed to higher seed yield resulting from better growth and yield attributes due to enhanced availability and uptake of nutrients. Higher seed yield coupled with low cost of cultivation resulted in higher B:C ratio in T<sub>1</sub>. The findings also indicated that nutrient management plays a vital role in boosting the income. Lower net return noted in T<sub>13</sub> might be due to the use of higher dose of fertilizers and corresponding higher cost which in turn increased the cost of cultivation. Optimum supply of nutrients resulted in higher seed yield due to reduction in nutrient losses and enhancement in the nutrient uptake resulting from the supply of nutrients in consonance with the crop growth.

Yadav *et al.* (2009) observed that application of 40:20:20:30 kg NPKS ha<sup>-1</sup> recorded the highest net return of 12787 ₹ ha<sup>-1</sup> and B:C ratio of 1.59 in sesame. Sujatha and Rao (2019) found that application of 40:20:20 kg NPK ha<sup>-1</sup>, resulted

in the highest gross return, net return and B:C ratio in sesame (42592 ₹ ha<sup>-1</sup>, 29202 ₹ ha<sup>-1</sup> and 2.18, respectively).

## 5.2 ASSESSING THE RESPONSE OF PROMISING SESAME VARIETIES TO IDENTIFIED OPTIMUM NUTRIENT LEVELS

### 5.2.1 Effect of Nutrient Levels and Varieties on Growth Characters of Sesame

The results in Tables 41-48 revealed that the growth characters of sesame varied significantly with the application of different level of nutrients. Among the nutrient levels, taller plants, higher number of leaves per plant, branches per plant and DMP were observed in n<sub>2</sub> (34:21:3 kg NPK ha<sup>-1</sup>) at all stages of growth. The result indicated that 34:21:3 kg NPK ha<sup>-1</sup> was the optimum nutrient dose for sesame for higher productivity in Southern Laterites.

Nitrogen, P and K are the primary nutrients, which plays a crucial role in plant metabolism. Better expression of growth parameters in n<sub>2</sub> (34:21:3 kg NPK ha<sup>-1</sup>) might be due to the availability of nutrients in the root zone. Adequate availability of nutrients coupled with enhanced nutrient uptake might have resulted in better expression of growth parameters. At 40 DAS and 60 DAS, the number of leaves per plant in n<sub>2</sub>, were 80.1 per cent and 71.7 per cent, higher than n<sub>5</sub> (KAU POP recommendation, 30:15:30 kg NPK ha<sup>-1</sup>). Nitrogen is the most important nutrient for vegetative growth, subsequent canopy development and photosynthetic efficiency. Bange *et al.* (2000) reported that optimum dose of N resulted in enhanced crop growth and development in sunflower. The results on growth parameters elucidated the sufficiency of 34 kg ha<sup>-1</sup> N for sesame in Southern Laterites. Results also indicated that the inherent status of available P and K were high in Southern Laterites, application of lower levels of P (21 kg ha<sup>-1</sup>) and K (3 kg ha<sup>-1</sup>) was adequate for the crop to produce higher yield. It is presumed that the enhanced root proliferation and absorption of water and nutrients, consequent to the application of optimum dose of nutrients resulted in better plant growth. Greater number of leaves indicated higher photosynthetic area and better interception of solar radiation. Improved assimilation of photosynthates, resulted in taller plants and more number of branches per plant. Pyne *et al.* (2022) opined that balanced

supply of N, P and K increased the photosynthetic ability of the plants. The DMP at 40 DAS, 60 DAS and harvest were 35.5 per cent, 51.9 per cent and 34.5 per cent, respectively higher than KAU, POP recommendation. Absorption of nutrients and effective translocation of photosynthates might have enhanced the dry matter accumulation in plants. Optimum supply of nutrients would have resulted in higher biomass production, which in turn led to higher DMP (Fig.22 and 23). Thorve *et al.* (2011) observed that application of 37.5: 18.5 kg NP ha<sup>-1</sup> was sufficient to produce taller plants (84.2 cm), greater number of leaves per plant (32.1) and number of branches per plant (3.7) at harvest, when the available K status of the soil was high. Ghosh *et al.* (2013) observed that application of 40:20:20 kg NPK ha<sup>-1</sup>, resulted in taller plants (80.1 cm), more number of branches per plant (3.4) and DMP at harvest (447.0 g m<sup>-2</sup>) in sesame.

Varieties differ in genetic potential and its productivity may vary in response to management practices. Chen *et al.* (2014) opined that preferential cultivation of high yielding and fertilizer responsive varieties were important to ensure food security, reduced fertilizer consumption and to mitigate climate change. Selection of suitable varieties for particular agro-ecological situation played a decisive role in augmenting the productivity of crops (Zhenrui *et al.*, 2015). Results also revealed that the growth parameters of sesame were significantly influenced by varieties. Among the varieties, GT 10 recorded higher values for growth parameters and was followed by Thilak (Tables 41-46). The variation in growth attributes observed among varieties were attributed to the inherent genetic variability in morphological characters of the varieties. Better growth characters observed in in GT 10 would also be due to higher nutrient uptake and subsequent translocation of nutrients from source to various parts of the plant. Different varieties showed variations in nutrient uptake and its utilization due to difference in the root morphology, ability to absorb and solubilize nutrients in the rhizosphere and source-sink relationships (Fageria *et al.*, 2015). Sawadhakar *et al.* (2023) observed that among the three varieties of sesame (TLT-10, TKG-22 and JLT-408), TLT- 10 resulted in taller plants (124.4 cm), more number of branches (5.5) and leaves per plant (51.7) at harvest.

The individual effect of nutrient levels and varieties were reflected in the interactions. GT 10 fertilized at 34:21:3 kg NPK ha<sup>-1</sup> (n<sub>2</sub>v<sub>5</sub>) resulted in better expression of growth parameters at all stages of growth. Optimum nutrient availability combined with better nutrient utilisation by the crop resulted in better expression of growth attributes. Subrahmaniyan and Arulmozhi (1999) observed that among the two sesame varieties VS 9104 and VRI 1, the variety VS 9104, fertilized with 45 kg N ha<sup>-1</sup> produced taller plants (120 cm), higher number of branches per plant (5.2) and DMP (30.1 g per plant).

### **5.2.2 Effect of Nutrient Levels and Varieties on Physiological Parameters of Sesame**

Leaf area index represents, the size of assimilatory surface of the crop. Increase in LAI is proportional to the amount of solar energy intercepted by canopy and represents the productive capacity of the crop. The results on LAI revealed that at 40 DAS and 60 DAS, n<sub>2</sub> had higher LAI (2.54 and 5.89, respectively) which was on par with n<sub>1</sub> (2.30 and 5.44, respectively). Leaf area index in n<sub>2</sub> were 80.1 per cent and 71.7 per cent, respectively higher than KAU POP recommendation at 40 DAS and 60 DAS (Fig. 25). Better root proliferation, increased nutrient uptake and its translocation might have resulted in greater number of leaves with larger photosynthetic area and consequently higher LAI. Nitrogen, being the most important nutrient for vegetative growth, application of optimum amount of N could enhance the leaf area and longevity. Sharma (2005) reported that application of optimum dose of NPK promoted the meristematic activity leading to production of greater number of leaves with larger leaf area in sesame. Verma *et al.* (2013) observed that application of 30:20:10 kg NPK ha<sup>-1</sup>, resulted in higher LAI at 30 DAS (3.3) and 60 DAS (4.6) compared to control.

The results also revealed that the LAI varied among the varieties at all stages of crop growth. Among the varieties, GT 10, emerged as the top performing variety with higher LAI at 40 DAS and 60 DAS. The results highlighted that the genetic ability of GT 10 helped to maintain higher LAI. Shilpa *et al.* (2022) observed that among the three varieties of sesame *viz.*, YLM 17, YLM 66 and Til 4, YLM 66

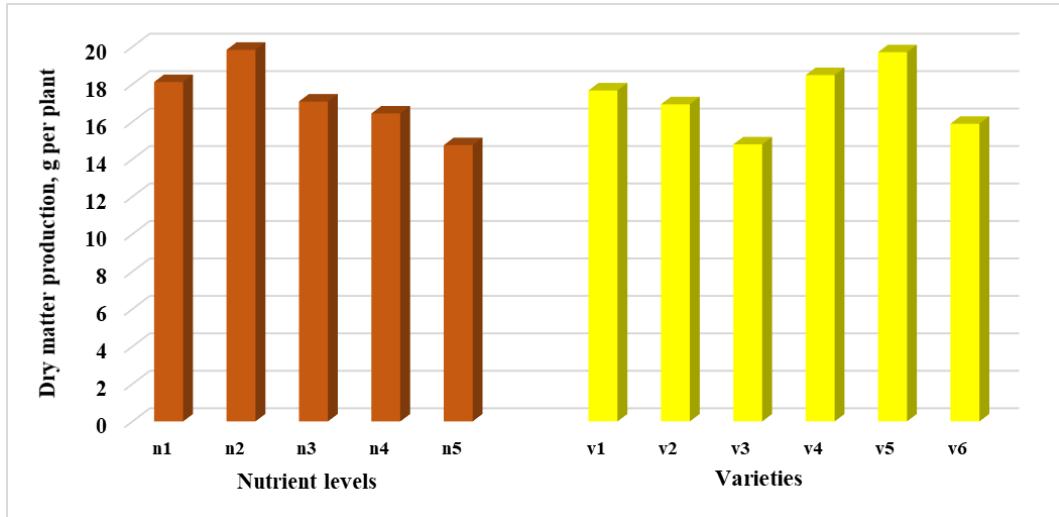


Fig. 23. Effect of nutrient levels and varieties on DMP at harvest during 2023-24

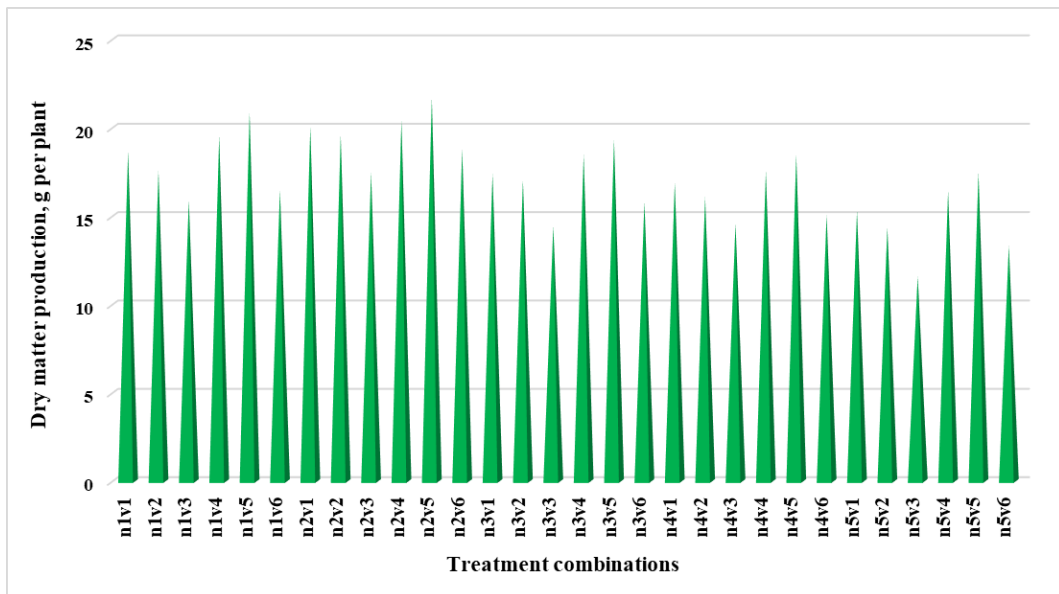


Fig. 24. Interaction effect of nutrient levels and varieties on DMP at harvest during 2023-24

produced the highest LAI at harvest (1.8). The interaction effects were also found to be significant at different growth stages (Fig.26). The cumulative effect of nutrient levels and varieties were observed in the interaction effect and the treatment combination n<sub>2</sub>v<sub>5</sub> recorded higher LAI at 40 DAS and 60 DAS. This could be attributed to the synergistic interaction of individual effects.

The chlorophyll content was also influenced by nutrient levels. The highest chlorophyll content was noted in n<sub>2</sub>. The chlorophyll content of the leaves was directly influenced by the photosynthetic capacity of the crop (Li *et al.*, 2018). Higher chlorophyll content usually indicates higher rate of photosynthesis, leading to production of higher amount of carbohydrates, consequently resulting in robust plant growth. Greater number of leaves and increased LAI in n<sub>2</sub> would have led to improved nutrient assimilation and enhanced chlorophyll content. Jamil *et al.* (2012) reported that application of optimum amount of N, P and K improved the structure of chloroplasts, enhanced the biosynthesis of chlorophyll and reduced the activity of chlorophyll degrading enzyme, chlorophyllase. In addition, optimum supply of N, enhanced the uptake of Mg, which serves as the central atom of chlorophyll molecule, enabling accumulation of more chlorophyll in the leaves (Fathi, 2022). The results also revealed that the chlorophyll content was higher at 60 DAS than 40 DAS. Samreen *et al.* (2017) opined that higher LAI at 60 DAS resulting from increased length and breadth of leaves increased the chlorophyll content of leaves at later stages of plant growth. Ahmad *et al.* (2022) opined that increase in chlorophyll content could also be the result of better assimilation of nutrients especially N.

A significant variation in the chlorophyll content was marked among the varieties. The results revealed that at 20 DAS and 60 DAS, the highest chlorophyll content was observed in GT 10 (v<sub>5</sub>). While at 40 DAS, higher chlorophyll content noted in GT 10 (v<sub>5</sub>) which was on par with Thilak (v<sub>4</sub>). Difference in chlorophyll content in the leaves observed among varieties at different stages might be due to difference in leaf size, shape etc. Higher chlorophyll content observed in GT 10 was due to better assimilation of nutrients. Mineral nutrition had positive effect on

N content of the plant which significantly influenced the chlorophyll content of the leaves. Tucker (2004) and Daughtry *et al.* (2000) revealed that N being the structural element of chlorophyll, increased N content in the leaves significantly influenced chloroplast formation and chlorophyll accumulation. The results depicted in Tables 51 and 52 revealed that the chlorophyll content was influenced by the interaction effect of nutrient levels and varieties. At 40 DAS, higher chlorophyll content was observed in  $n_2v_5$  which was on par with  $n_2v_4$ ,  $n_1v_5$  and  $n_2v_1$ . While at 60 DAS, higher chlorophyll content was observed in  $n_2v_5$  which was on par with  $n_1v_5$  and  $n_2v_4$ . Higher chlorophyll content in these treatments could be attributed to the combined effect of nutrient level  $n_2$  with the varieties  $v_5$ ,  $v_4$  and  $v_1$ .

Crop growth rate and RGR are the useful parameters in estimating the production efficiency of the crop. It was evident from the results that the CGR and RGR were significantly influenced by nutrient levels. The highest CGR and RGR were observed in  $n_2$  at all time intervals. This might be due to higher dry matter partitioning resulting from better expression of growth parameters, LAI and chlorophyll content. Amanullah *et al.* (2008) reported that higher leaf area enhanced the light interception which eventually increased the DMP, CGR and RGR at different growth stages.

Significant difference in CGR and RGR were also observed among varieties. GT 10 ( $v_5$ ) recorded higher CGR at 20 DAS-40 DAS and 40 DAS-60 DAS. At 40 DAS-60 DAS, GT 10 was on par with Thilak ( $v_4$ ). While, the RGR was influenced by the varieties only at 20 DAS-40 DAS and GT 10 ( $v_5$ ) recorded the highest RGR. Higher LAI and DMP might have resulted in higher CGR and RGR in GT 10. The variations in CGR and RGR observed among the varieties might be due to the difference in genetic makeup. Kumar (2008) reported that high yielding genotypes of moth bean showed higher CGR and RGR. Similar observations were also observed by Bhadauria *et al.* (2018) and Meena *et al.* (2022) in cluster bean.

The interaction effects suggested that the nutrient levels and varieties had significant influence on CGR and RGR. This would be the reflection of individual effect of nutrient levels and varieties. Among the interactions,  $n_2v_5$  resulted in

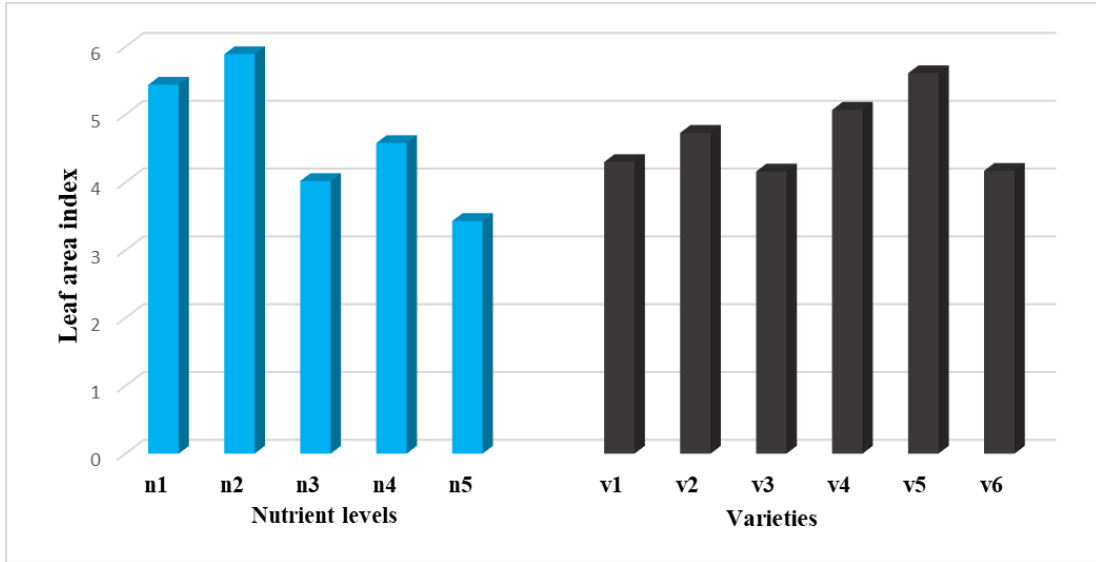


Fig. 25. Effect of nutrient levels and varieties on LAI at 60 DAS during 2023-24

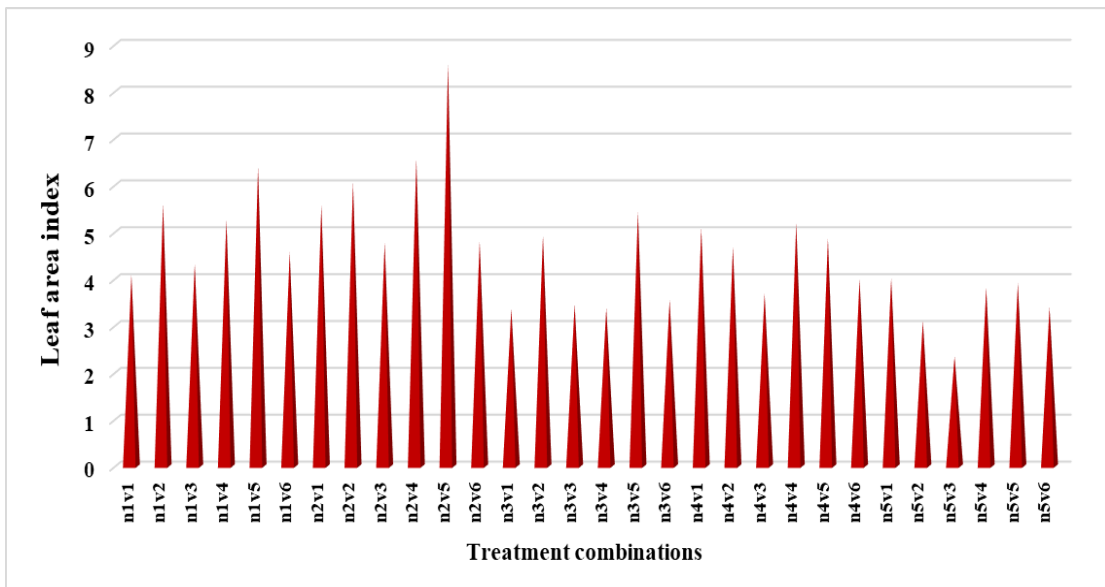


Fig. 26. Interaction effect of nutrient levels and varieties on LAI at 60 DAS during 2023-24

higher CGR and RGR. A combined impact of optimum availability of nutrients in  $n_5$  with the high yielding variety GT 10 might have resulted in the highest CGR and RGR in  $n_2V_5$ .

### **5.2.3 Effect of Nutrient Levels and Varieties on Yield Attributes and Yield of Sesame**

The results of the experiment revealed that the nutrient levels did not exert significant influence on days to 50 per cent flowering and hundred seed weight of sesame. This indicated that the nutrient levels had negligible effect on time of flower initiation and weight of hundred seeds. However, the number of capsules per plant (Fig.27) and seeds per capsule were significantly influenced by nutrient levels. The treatment  $n_2$  (34:21:3 kg NPK ha<sup>-1</sup>) resulted in greater number of capsules per plant and was on par with  $n_1$ . Better expression of yield attributes in  $n_1$  and  $n_2$  might be attributed to improved nutrient availability (Tables 72 and 73) leading to better root development and nutrient uptake. Bindraban *et al.* (2015) suggested that optimum availability and better uptake of nutrients were crucial for obtaining higher seed yield in crops. Similarly, greater number of leaves and chlorophyll content would have enhanced the rate of photosynthesis and dry matter partitioning. The fulfilment of crop demand by enhanced assimilation through the optimum supply of nutrients and the corresponding increase in translocation of photosynthates from source to sink might have resulted in the better expression of yield attributes in  $n_2$  and  $n_1$ .

The variations observed in the number of capsules per plant, seeds per capsule and hundred seed weight among the varieties reflected the genetic differences of sesame varieties. The morphological parameters such as plant height and branching ability of different varieties have eventually influenced the number of capsules per plant. GT 10 was observed as the best performing variety of sesame in Southern Laterites followed by Thilak, Kayamkulam 1, Thilathara and TMV 7. Higher yield attributes in GT 10 could be positively related to its improved growth attributes. In contrast, the variety, Thilarani, exhibited lower yield attributes. The variations in yield attributes among the varieties might be due to differences in their

genetic yield potential. Mekonnen *et al.* (2016) observed that sesame variety 'Barsan' recorded the greatest number of capsules per plant and seed yield compared to varieties 'Mehado- 80' and 'Adi'. Wacal *et al.* (2019) suggested that sesame variety 'Gomazou' resulted in the highest seed yield compared to 'Marushime' owing to its genetic superiority over the latter. The findings implied that varietal selection significantly influenced the yield attributes *viz.*, the number of capsules per plant, seeds per capsule and hundred seed weight of sesame. The results indicated that GT 10 was the best performing variety of sesame for Southern Laterites, while least preferable one was Thilarani.

The results also revealed that the interaction between nutrient levels and varieties had significant influence on the number of capsules per plant (Fig. 28). The combination  $n_2v_5$  resulted in the highest number of capsules per plant followed by  $n_2v_4$ . This suggested that the varieties may respond differently to specific nutrient levels. The interaction effects highlighted the potential of nutrient levels and different varieties for optimizing the yield attributes.

Results on yield revealed that the highest seed yield per plant and seed yield  $ha^{-1}$  were observed in  $n_2$  (Fig.29). Shen *et al.* (2013) opined that application of optimum dose of fertilizers should be extensively practiced to maintain soil fertility and sustain crop yield. According to Howlader *et al.* (2018) the yield of a crop was governed by the activity of source and translocation and accumulation of carbohydrates to the sink. Higher seed yield in  $n_2$  might be attributed to better expression of growth attributes and physiological parameters *viz.* number of leaves, LAI and chlorophyll content indicating better source strength and photosynthetic activity leading to increased sink. The seed yield is a function of yield attributes, such as number of capsules per plant and seeds per capsule. Higher seed yield realized in  $n_2$  might be the result of better yield attributes. Influx of large amount of photosynthetic assimilates to the reproductive structures might have resulted in the highest seed yield in  $n_2$ . Kaur *et al.* (2015) opined that the seed yield was the cumulative expression of growth and yield attributes.



Plate 11. Capsules of different sesame varieties chosen for the study



Plate 12. Seeds of different sesame varieties chosen for the study

The results on seed yield also revealed the superiority of statistical design CCD, over RBD in optimizing the nutrient levels for specific AEU's. The highest seed yield per hectare obtained from CCD ( $n_2$ ) was 14.3 per cent higher than that obtained from RBD ( $n_4$ ). It was adjudged from the results that 34:21:3 kg NPK  $ha^{-1}$  was sufficient to realize the highest seed yield of sesame in Southern Laterites. The results endured that N and P requirements were slightly higher than the blanket recommendation by 8.4 per cent and 5.5 per cent, respectively. However, only 3 kg K  $ha^{-1}$  was required, which is 90 per cent, lesser than the blanket recommendation. This reduction could be due to high initial K status of soil. The soil in Southern Laterites had medium to high K status, hence application of 3 kg  $ha^{-1}$  K was sufficient to meet the nutrient requirement of the crop. In soils with high initial K status application of higher rate of K may resulted in salt damage, consequently affecting the absorption of water and other nutrients such as Ca and Mg, inducing severe defoliation, leading to reduction in photosynthetic area and yield. (Alva *et al.*, 2006).

Among the varieties the highest seed yield was observed in GT 10, followed by Thilak, Kayamkulam 1, Thilathara, TMV 7 and Thilarani. Higher seed yield in GT 10 could be due to better expression of growth parameters such as more number of leaves per plant, branches per plant, higher DMP, LAI and physiological parameters such as chlorophyll content and its cumulative effect of yield attributing characters. The results underlined the importance of selecting a potential variety for higher seed yield in particular AEU. Sharar *et al.* (2000) observed that sesame genotype TS-3 gave significantly higher seed yield than the other genotypes in Faisalabad due to the cumulative effect of yield attributes *viz.*, greater number of capsules per plant, seeds per capsule and thousand seed weight.

Significant interaction between nutrient levels and varieties was observed in seed yield per plant and seed yield  $ha^{-1}$  of sesame. The treatment combination  $n_2v_5$  resulted in the highest seed yield (Fig.30). The interaction effect indicated that nutrient levels and choice of variety could collectively affect the seed yield. The results evinced that certain varieties performed better under specific nutrient levels, and such results could be a valuable tool for varietal selection and nutrient

recommendation for crops in specific areas. Kashani *et al.* (2015) revealed that interactive effects between nutrients and varieties significantly influenced the seed yield in sesame. The highest seed yield (782.7 kg ha<sup>-1</sup>) was obtained with the application of N and P each at 70 kg ha<sup>-1</sup> in variety S-17.

The results on the haulm yield per plant and haulm yield ha<sup>-1</sup> revealed that higher haulm yield was obtained at nutrient level n<sub>2</sub> and was on par with n<sub>1</sub>. Higher vegetative growth envisaged with the application of optimum amount of nutrients might have enhanced the uptake of nutrients, eventually resulting in increased haulm yield. Among the varieties, the highest haulm yield was observed in GT 10 due to taller plants with higher production of leaves, branches and DMP.

The interaction effect between the nutrients and varieties were significant and the treatment n<sub>2</sub>v<sub>5</sub> resulted in higher haulm yield. This would be the reflection of the cumulative effect of nutrient level n<sub>2</sub> and the variety GT 10.

Harvest index is the measure of photosynthetic efficiency of the crop and is interpreted as the ability to convert dry matter accumulation to economic produce. The results on the effect of the nutrient levels on HI indicated that HI was higher in n<sub>2</sub> which was on par with n<sub>1</sub>. Higher seed yield in n<sub>2</sub> might have contributed to higher HI. Foulkes *et al.* (2013) opined that increased sink size or improved partitioning of assimilates to reproductive tissues might have resulted in higher HI. Among the varieties higher HI was observed in GT 10 (v<sub>5</sub>) which was on par with Thilak (v<sub>4</sub>). This could be due to higher seed yield in GT 10, resulting from the production of more number of capsules per plant and seeds per capsule. Zhang *et al.* (2012) observed that varieties with genetic superiority either improved the seed yield or increased the remobilization of assimilates from vegetative tissues to seeds after anthesis, resulting in higher HI.

The interaction effect revealed that n<sub>2</sub>v<sub>5</sub> recorded higher HI, which was on par with n<sub>2</sub>v<sub>4</sub> and n<sub>1</sub>v<sub>5</sub>. The interaction effect could be considered as the cumulative effect of individual effects of nutrient level n<sub>2</sub> and variety GT 10. Porker *et al.* (2020) opined that HI was determined by the interactions between genotypes and

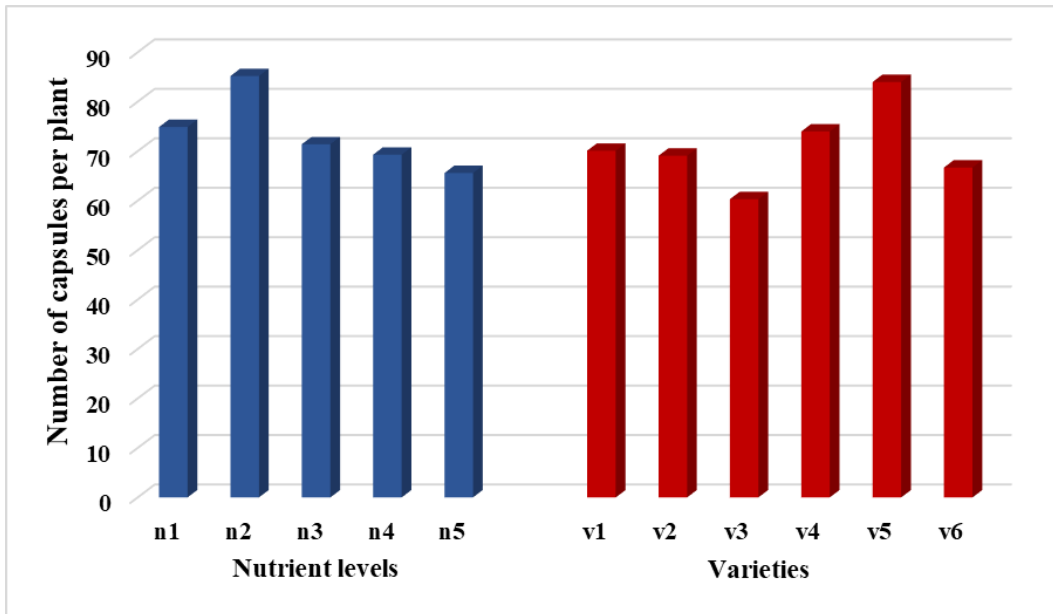


Fig. 27. Effect of nutrient levels and varieties on number of capsules per plant during 2023-24

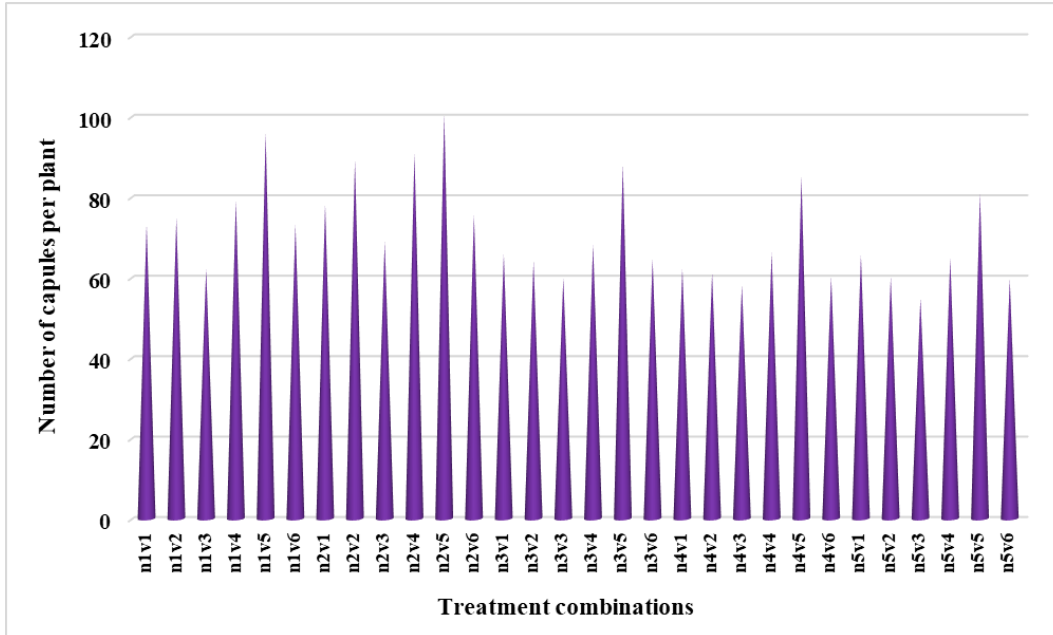


Fig. 28. Interaction effect of nutrient levels and varieties on number of capsules per plant during 2023-24

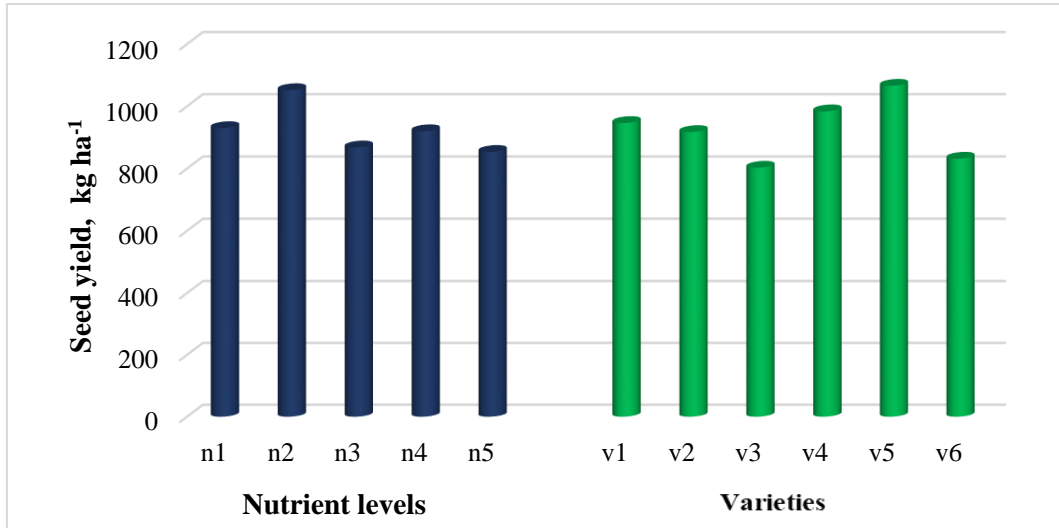


Fig. 29. Effect of nutrient levels and varieties on seed yield ha<sup>-1</sup>

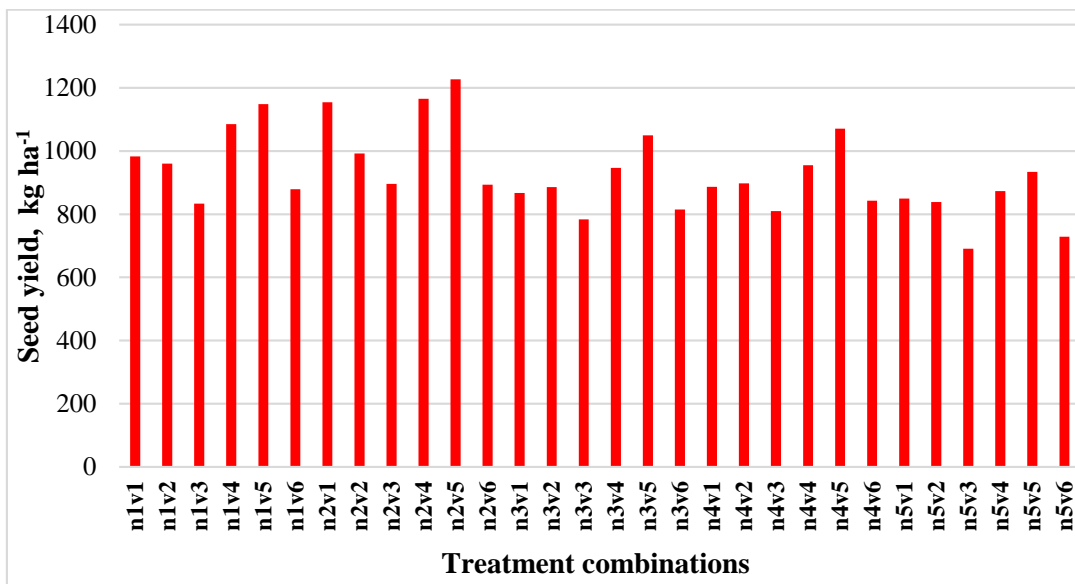


Fig. 30. Interaction effect of nutrient levels and varieties on seed yield ha<sup>-1</sup>



Plate 13. Best treatment during 2023-24 ( $n_2v_5$ : 34:21:3 kg NPK ha<sup>-1</sup> × GT 10)

nutrient management practices.

#### **5.2.4 Effect of Nutrient Levels and Varieties on Quality Parameters of Sesame**

The results pertaining to quality parameters revealed that the oil content and crude protein content of sesame were not significantly influenced by the individual effect of nutrient levels and varieties and their interactions. However, higher P content was observed in  $n_2$  which was on par with  $n_1$  and  $n_3$ . Among the nutrient levels, the highest Mg and Fe content were recorded in nutrient level  $n_2$ . While, higher Ca and Zn content were noted in  $n_2$  which was on par with  $n_1$ . Enhanced nutrient availability coupled with better uptake of nutrients might have resulted in improved quality parameters in the seeds. Quality crop production required optimum supply of nutrients especially the major nutrients, N, P and K based on the soil conditions and developmental stages of crop (Marschner, 2012; Dick and Culman, 2016). Njira and Nabwami (2015) opined that application of optimum quantity of nutrients (N, P and K) was of profound importance, as the quality parameters were greatly influenced by the synergistic or antagonist interaction between the nutrients utilized by the crop. Ishfaq *et al.* (2023) observed that application of optimum dose of fertilizers improved the nutritional quality by enhancing the content of mineral nutrients (K, Ca, Mg, Zn and Fe) in the seeds of food crops.

Similarly, among the varieties higher content of P, Ca and Mg in the seeds were observed in GT 10. The variations in the nutrient profile of varieties highlighted the genetic variability and inherent characteristics of varieties which implied the importance of varietal selection in exhibiting superior quality. Kim *et al.* (2007) opined that the quality parameters of sesame cultivars were genetically controlled.

The interaction effect between nutrient levels and varieties had significant effect on P, Ca and Mg content of seeds. The interaction effects suggested that the nutrient levels had significant impact on the expression of quality parameters when combined with specific varieties. Cakmak and Kutman (2018) opined that selection

of suitable varieties and fertilizer management were the best approaches for enhancing the nutritional quality of agricultural produce.

### **5.2.5 Effect of Nutrient Levels and Varieties on Nutrient Uptake by sesame**

Nutrient levels had significant impact on nutrient uptake by the crop. The amount of total nutrient uptake by sesame was in the order of N>K>P. Higher NPK uptake was observed at nutrient level n<sub>2</sub>. The total N, P and K uptake in n<sub>2</sub> were 31.5 per cent, 7.6 per cent and 15.8 per cent, respectively, higher than KAU POP recommendation. The nutrient uptake is directly related to the nutrient content and DMP of the crop. Higher NPK uptake by sesame in n<sub>2</sub> might be attributed to its higher DMP. Hailu *et al.* (2015) reported that nutrient uptake by crops could be significantly improved by the application of optimum level of N, P and K.

Similarly the results revealed that varieties had significant effect on total nutrient uptake. Among the varieties, higher nutrient uptake observed in GT 10 due to its DMP. This indicated the potential of differential absorption and variation in DMP among the tested varieties. Nipa *et al.* (2013) observed that different varieties of same crop showed difference in the nutrient absorption and utilization. Piekutowska *et al.* (2021) opined that varieties had significant impact on absorption of nutrients *viz.*, N, P and K.

The interaction effect revealed that the nutrient levels and varieties had significant influence on nutrient uptake. The highest nutrient uptake was observed in the treatment n<sub>2</sub>v<sub>5</sub>. The results implied that the choice of varieties and nutrient levels offered valuable insights in influencing the nutrient uptake by the crop.

### **5.2.6 Effect of Nutrient Levels and Varieties on Organic Carbon Content in the Soil and Nutrient Availability**

The results on post-harvest soil analysis revealed that the nutrient levels and varieties significantly influenced the available nutrient status of N, P and K in the soil.

Perusal of data revealed that nutrient level,  $n_2$  resulted in higher available N in the soil which was on par with  $n_1$  and  $n_4$ . However, higher available P and K were observed in  $n_2$  which was on par with  $n_1$ . Conversely, the lowest available N, P and K were observed in  $n_5$ . Application of optimum amount of nutrients might have enhanced the rhizo-deposition of nutrients in the soil. Chen *et al.* (2009) opined that long term indiscriminate application of fertilizers resulted in severe degradation of soil, characterized by high acidity and low nutrient status. Kannan *et al.* (2013) opined that application of optimum dose of nutrients, improved soil fertility by increasing the soil available nutrients. Jiang *et al.* (2024) observed that optimum NPK fertilization improved the root growth and secretion of root exudates, facilitating mineralization and increased availability of soil N, P and K. Application of optimum dose of fertilizers improved the amount of available nutrients in the root zone and eventually increased the crop yield (Xu *et al.*, 2022).

Varieties were also identified to influence the soil available N, P and K. Among the varieties, the highest available N and P were observed in GT 10. However, higher available K was observed in GT 10 which was on par with Thilak. In contrast, the lowest available nutrients were recorded in Thilarani. The superior genetic potential of GT 10 might have augmented the release of root exudates, resulting in solubilisation of fixed forms of nutrients and improved nutrient availability.

The interaction effect was significant only for available N and the results revealed that higher available N was observed in  $n_2v_5$ . The interaction effect could be considered as a reflection of the individual effect of  $n_2$  and  $v_5$ . The results suggested that the choice of varieties and nutrient levels had significant impact on available N in the soil.

### **5.2.7 Effect of nutrient levels and varieties on economics of cultivation**

The results in Tables 74, 75 and 76 revealed that the highest gross return, net return and B:C ratio were observed in nutrient level  $n_2$  (34:21:3 kg NPK ha<sup>-1</sup>). Among the varieties, the highest gross return, net return and B:C ratio were observed in  $v_5$

(GT 10). Similarly, among the interactions the highest gross return, net return and B:C ratio were observed in n<sub>2</sub>v<sub>5</sub>.

The results endorsed that the nutrient levels and varietal selection had substantial influence on the economics of cultivation of sesame. Optimum nutrient dose is important for improving the nutrient use efficiency and reducing the cost of cultivation. Significantly higher seed yield realized in n<sub>2</sub>v<sub>5</sub> was due to the cumulative effect of optimum dose of nutrients and varieties which resulted in higher income. Optimal nutrient levels prevented the over use of fertilizers thereby lowering cultivation costs.

Sawadhakar *et al.* (2023) observed that among the sesame varieties *viz.*, TLT-10, TKG-22 and JLT-408, TLT-10 recorded the highest gross return (77,005 ₹ ha<sup>-1</sup>), net return (35,085 ₹ ha<sup>-1</sup>) and B:C ratio (1.81). Krishnaveni *et al.* (2024) found that application of 40:20:20 kg NPK ha<sup>-1</sup> resulted in higher gross return (57,959 ₹ ha<sup>-1</sup>), net return (34,341 ₹ ha<sup>-1</sup>) and B:C ratio (1.45) in sesame. Kumara *et al.* (2014) observed that application of 40:25:25 kg NPK ha<sup>-1</sup> sesame variety DS-1, resulted in the highest gross return (26,660 ₹ ha<sup>-1</sup>) and net return (15,480 ₹ ha<sup>-1</sup>). While, B:C ratio of DS-1 (2.38) was statistically on par with variety DSS-9 (2.37).

### 5.3 ASSESSMENT OF ALLELOPATHIC POTENTIAL OF SESAME

#### 5.3.1 Assessment of Allelopathic Effect of Sesame on Selected Weeds

Leachates of different sesame varieties had significant inhibitory effect on germination and seedling growth of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*. Application of leachate of variety GT 10 registered the lowest germination percentage in *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus* (16.65%, 13.35% and 10.00%, respectively). Similarly, the seedling growth parameters *viz.*, seedling shoot length, root length, fresh weight and dry weight of all the tested weeds were significantly inhibited by leachate of variety GT 10. The SVI I of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus* were 92.60 per cent, 94.00 per cent and 95.80 per cent lower than control, with the application of GT 10 leachate. While, SVI II of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus*

*rotundus* were 90.85 per cent, 94.37 per cent and 96.86 per cent lower than control, with the application of leachate of variety GT 10.

Inhibitory effects of sesame varieties might be due to the presence of allelochemicals present in the whole plant leachates. Sesame contains several secondary metabolites, among which phenolic acids (18%), lipids (16%), flavonoids (14%), amino acid derivatives (9%) and alkaloids (5%) were the major chemical classes (Dossou *et al.*, 2021). Emulsion concentrate (EC) of sesame root exudate (240  $\mu\text{g g}^{-1}$ ) inhibited the germination of broad leaf weeds *viz.*, *Chenopodium album*, *Anagallis arvensis* and *Melilotus alba* by 80 per cent, 75 per cent and 65 per cent, respectively over control. While, EC of sesame root exudates at 280  $\mu\text{g g}^{-1}$  of soil inhibited the shoot and root biomass of *Chenopodium album* by 86 per cent and 89 per cent, *Anagallis arvensis* by 46 per cent and 58 per cent and *Melilotus alba* by 42 per cent and 72 per cent respectively over control (Kumar and Varshney, 2007).

Dat *et al.* (2016) opined that leaves of sesame contains specific chemicals like epigallocatechin, 3-epibartogenic acid and kaempferol derivatives that hinder the activity of  $\alpha$ - amylase, involved in germination. Leachate of sesame leaves (100%) inhibited the sprouting of *Cyperus rotundus* rhizomes by 53.33 per cent compared to control (Hussain *et al.*, 2017). Zhao *et al.* (2022) opined that aqueous extract of different plant parts of sesame (root, stem and leaf) at 100 mg mL<sup>-1</sup> delayed seed germination and reduced the shoot and root length of Moso bamboo (*Phyllostachys edulis*).

### **5.3.2 Assessment of Allelopathic Effect of Sesame on Selected Crops**

The results revealed that application of leachate of variety GT 10 resulted in the lowest number of seeds germinated and germination percentage in cowpea (1.67% and 16.70%, respectively) and okra (5.00 and 50.00%, respectively). The seedling shoot length of cowpea and okra treated with the leachate of variety GT 10 were 64.18 per cent and 54.76 per cent, respectively lower than the control and seedling root length of cowpea and okra were 57.63 per cent and 48.30 per cent, respectively lower than the control. Similarly, the seedling fresh weight of cowpea

and okra, treated with the leachate of variety GT 10 were 55.77 per cent and 52.77 per cent, respectively lower than control and seedling dry weight of cowpea and okra were 47.62 per cent and 70 per cent, respectively lower than control. The SVI I and SVI II of cowpea and okra were also significantly inhibited by the application of leachate of variety GT 10. However, the germination and seedling growth of amaranthus were not significantly influenced by the leachates.

Premature lignification caused by allelochemicals arrested the growth of plants and resulted in inferior expression of growth attributes (Santosh *et al.*, 2004). Zhu *et al.* (2005) opined that allelopathic response of plants depend on the type and concentration of allelochemicals. The variety GT-10 might have higher concentration of allelochemicals, resulting in higher level of inhibitory effect. Impaired metabolic activities in response to allelochemicals in the leachate might have decreased shoot length and root length of both cowpea and okra. The phenolic allelochemicals inhibits cell division, alters the cell structure and could impede the absorption of water and nutrients leading to production of dwarf plants (John, 2012; Scavo *et al.*, 2018)

Similar findings were reported by Yuprasoet *et al.* (1992) that sesame whole plant extract (5%) inhibited the seedling shoot and root length of mung bean, peanut, corn and sorghum. Oudhia and Tripathi (2000), which demonstrated that sesame leaf extract (1:10 w/v) significantly inhibited the germination and seedling vigour of rice. Shah *et al.* (2016) revealed the inhibitory effect of sesame on the growth and yield attributes of green gram grown in replacement series.

It is conclusively evident from the results that suitable variety has to be selected for each AEU for realizing the potential yield. The variety GT 10 raised under partial shade of coconut gardens with 5 t ha<sup>-1</sup> of FYM + 34:21:3 kg NPK ha<sup>-1</sup> (full dose of P, K and 75 per cent N as basal application and 25 per cent N as foliar spray at 3 per cent concentration, 30 DAS) realized the highest seed yield, net return and B:C ratio for sesame in Southern Laterites. Application of leachate of variety GT 10 had significant inhibitory effect on the germination and growth of tested weeds (*Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*) and crops (cowpea



Plate 14. Inhibitory effect of leachate of variety GT 10 on *Alternanthera sessilis*



Plate 15. Inhibitory effect of leachate of variety GT 10 on *Setaria barbata*



Plate 16. Inhibitory effect of leachate of variety GT 10 on *Cyperus rotundus*



Plate 17. Inhibitory effect of leachate of variety GT 10 on cowpea



Plate 18. Inhibitory effect of leachate of variety GT 10 on okra

and okra).

**AGRO-TECHNIQUES FOR SESAME (*Sesamum indicum* L.)  
UNDER PARTIAL SHADE OF COCONUT IN  
SOUTHERN LATERITES**

*by*

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# **SUMMARY**

## 6. SUMMARY

The experiment entitled “Agro-techniques for sesame (*Sesamum indicum* L.) under partial shade of coconut in Southern Laterites” was undertaken with the objectives to standardize the nutrient levels for sesame under partial shade of coconut in Southern Laterites, assess the response of promising sesame varieties to the identified optimum nutrient levels and evaluate the allelopathic effect of sesame on selected weeds and crops.

Field experiments were conducted at Coconut Research Station, Balaramapuram, Kerala to optimize the fertilizer dose for sesame in Southern Laterites, during *Rabi*, 2021-22 and 2022-23. The experiment was laid out in central composite design, with 20 runs *viz.*, T<sub>1</sub>:31:20:16 kg NPK ha<sup>-1</sup>, T<sub>2</sub>:64:20:16 kg NPK ha<sup>-1</sup>, T<sub>3</sub>:31:50:16 kg NPK ha<sup>-1</sup>, T<sub>4</sub>:64:50:16 kg NPK ha<sup>-1</sup>, T<sub>5</sub>:31:20:34 kg NPK ha<sup>-1</sup>, T<sub>6</sub>:64:20:34 kg NPK ha<sup>-1</sup>, T<sub>7</sub>:31:50:34 kg NPK ha<sup>-1</sup>, T<sub>8</sub>:64:50:34 kg NPK ha<sup>-1</sup>, T<sub>9</sub>:20:35:25 kg NPK ha<sup>-1</sup>, T<sub>10</sub>:75:35:25 kg NPK ha<sup>-1</sup>, T<sub>11</sub>:48:10:25 kg NPK ha<sup>-1</sup>, T<sub>12</sub>:48:60:25 kg NPK ha<sup>-1</sup>, T<sub>13</sub>:48:35:10 kg NPK ha<sup>-1</sup>, T<sub>14</sub>:48:35:40 kg NPK ha<sup>-1</sup> and T<sub>15</sub> to T<sub>20</sub>: 48:35:25 kg NPK ha<sup>-1</sup>, replicated thrice. The variety used for the study was Thilak. The nutrient dose for sesame in Southern Laterites was standardized by plotting the response surface curves using the seed yield of sesame during both years. All the remaining observations were statistically analyzed using randomized block design with fifteen treatments (T<sub>1</sub>-T<sub>14</sub>, same as that of CCD, T<sub>15</sub>: average of treatments T<sub>15</sub>-T<sub>20</sub> in CCD), replicated thrice.

The growth parameters *viz.*, plant height, number of leaves per plant, number of branches per plant and DMP were significantly influenced by different nutrient levels. Perusal of data on growth attributes revealed that 31:20:16 kg NPK ha<sup>-1</sup> (T<sub>1</sub>) produced taller plants at 20 DAS, 40 DAS, 60 DAS and harvest during 2021-22 and 2022-23. At 20 DAS and 60 DAS, T<sub>1</sub> was on par with T<sub>2</sub> (64:20:16 kg NPK ha<sup>-1</sup>), during both years. While, at 40 DAS, T<sub>1</sub> was on par with T<sub>2</sub>, during 2022-23. At harvest, T<sub>1</sub> was on par with T<sub>2</sub> during 2021-22 and with T<sub>2</sub> and T<sub>4</sub> (64:50:16 kg NPK ha<sup>-1</sup>), during 2022-23. During both years, greater number of leaves per plant were observed T<sub>1</sub> at 20 DAS, 40 DAS and 60 DAS. However, at 20

DAS during 2021-22, it was on par with T<sub>7</sub> (31:50:34 kg NPK ha<sup>-1</sup>) and T<sub>2</sub> and with T<sub>2</sub> only during 2022-23. At 40 DAS, T<sub>1</sub> was on par with T<sub>2</sub> during 2022-23. At harvest during 2021-22, T<sub>1</sub> resulted in significantly greater number of leaves. At 40 DAS, 60 DAS and harvest during 2021-22, T<sub>1</sub> resulted in greater number of branches per plant and was on par with T<sub>2</sub>. While during 2022-23, T<sub>1</sub> resulted in greater number of branches per plant and was on par with T<sub>2</sub> and T<sub>4</sub> at 40 DAS and with T<sub>2</sub> at 60 DAS. However, T<sub>2</sub> produced greater number of branches per plant and was on par with T<sub>1</sub> at harvest. During both years, DMP was significantly higher in T<sub>1</sub> at all stages of observation.

The physiological parameters were also significantly influenced by different nutrient levels. During 2021-22, T<sub>1</sub> resulted in higher LAI at 20 DAS, 40 DAS and 60 DAS. However, at 20 DAS and 60 DAS, it was on par with T<sub>2</sub> and T<sub>4</sub> and at 40 DAS it was on par with T<sub>2</sub>. During 2022-23, T<sub>2</sub> resulted in higher LAI and was on par with T<sub>1</sub> at 20 DAS. However, at 40 DAS, T<sub>1</sub> resulted in higher LAI and was on par with T<sub>2</sub> and T<sub>4</sub> and at 60 DAS it was on par with T<sub>2</sub>, respectively. Similarly, higher chlorophyll content at 20 DAS and 40 DAS were observed in T<sub>1</sub>. At 40 DAS during 2021-22, T<sub>1</sub> was on par with T<sub>2</sub> and with T<sub>2</sub> and T<sub>4</sub> during 2022-23. At 60 DAS during 2021-22, T<sub>2</sub> resulted in higher chlorophyll content and was on par with T<sub>1</sub> and T<sub>4</sub>. At 20 DAS-40 DAS during 2021-22, higher CGR was observed in T<sub>1</sub> and was on par with T<sub>2</sub>. While at 40 DAS-60 DAS during both years, T<sub>1</sub> resulted in higher CGR and was on par with T<sub>2</sub>, T<sub>4</sub> and T<sub>7</sub>. At 60 DAS-harvest during 2021-22, higher CGR was noted in T<sub>1</sub> and was on par with T<sub>2</sub> and T<sub>4</sub>. During 2021-22 at 20 DAS-40 DAS, higher RGR was noted in T<sub>1</sub> and was on par with T<sub>2</sub>, T<sub>4</sub>, T<sub>7</sub> and T<sub>11</sub>. Similar trend was observed during both years at 40 DAS-60 DAS. However, the effect was not significant at 60 DAS-harvest.

During both years, the greatest number of capsules per plant (57.7 and 74.7, respectively), greater number of seeds per capsule were observed in T<sub>1</sub> and was on par with T<sub>2</sub> during 2021-22 and with T<sub>2</sub> and T<sub>4</sub> during 2022-23.

The highest seed yield was observed in T<sub>1</sub> during both years (503.5 kg ha<sup>-1</sup> and 554.7 kg ha<sup>-1</sup>, respectively). The haulm yield and harvest index were higher in T<sub>1</sub> and was on par with T<sub>2</sub> during both years.

The pooled analysis of seed yield obtained from RBD revealed that the highest seed yield was observed in T<sub>1</sub> (529.1 kg ha<sup>-1</sup>). The optimum NPK requirement for sesame in Southern Laterites was determined by plotting the response surface curves using seed yield in CCD design. During 2021-22, 35:26:7 kg NPK ha<sup>-1</sup> and 34:21:3 kg NPK ha<sup>-1</sup> and during *Rabi* 2022-23, 34:35:3 kg NPK ha<sup>-1</sup>, were identified as the optimum nutrient doses for sesame in Southern Laterites.

Significantly higher oil content was observed in T<sub>1</sub>, during 2021-22 and was not significant during 2022-23. Higher crude protein content was observed in T<sub>1</sub> and was on par with T<sub>2</sub>, during 2021-22. While, T<sub>2</sub> resulted in higher crude protein content and was on par with T<sub>1</sub> and T<sub>4</sub>, during 2022-23. However, higher P, Mg and Fe content in the seeds were observed in T<sub>2</sub> during both years. The calcium was significant only during 2022-23 and T<sub>1</sub> resulted in higher Ca content of the seeds. Similar trend was observed in Zn content during 2021-22.

Post experiment soil analysis revealed that T<sub>1</sub> resulted in higher organic carbon content, available N, P and K contents. Similarly, T<sub>1</sub> resulted in higher total N, P, and K uptake by sesame. However total N and K uptake by sesame were on par with T<sub>2</sub>, during 2021-22.

The results on economics of cultivation during both years revealed that the highest gross return, net return and B:C ratio were observed in T<sub>1</sub>.

Field experiment was conducted in CRS, Balaramapuram, during 2023-24 to validate the identified optimum dose of nutrients in six promising varieties of sesame. The experiment was laid out in split plot design. The main plot treatments included five nutrient levels *viz.*, 35:26:7 kg NPK ha<sup>-1</sup> (n<sub>1</sub>), 34:21:3 kg NPK ha<sup>-1</sup> (n<sub>2</sub>), 34:35:3 kg NPK ha<sup>-1</sup> (n<sub>3</sub>), 31:20:16 kg NPK ha<sup>-1</sup> (n<sub>4</sub>) and 30:15:30 kg NPK ha<sup>-1</sup> (n<sub>5</sub>) and the sub plot treatments included six sesame varieties *viz.*, Kayamkulam 1 (v<sub>1</sub>), Thilathara (v<sub>2</sub>), Thilarani (v<sub>3</sub>), Thilak (v<sub>4</sub>), GT 10 (v<sub>5</sub>) and TMV 7 (v<sub>6</sub>).

The nutrient levels had significant influence on the growth parameters. Among the nutrient levels, n<sub>2</sub> resulted in taller plants at 20 DAS, 40 DAS and 60 DAS, which was on par with n<sub>3</sub> at 20 DAS and with n<sub>3</sub> and n<sub>4</sub>, at 40 DAS and 60 DAS. At harvest, n<sub>2</sub> was significantly superior over other treatments. Similarly at 40 DAS and 60 DAS, number of leaves per plant and branches per plant were found to

be greater in  $n_2$ . At 40 DAS, 60 DAS and harvest the highest DMP were observed in  $n_2$ .

Among the physiological parameters,  $n_2$  resulted in higher LAI, which was on par with  $n_1$ , at 40 DAS and 60 DAS. Similarly, at 60 DAS, higher chlorophyll content was observed in  $n_2$  and was on par with  $n_1$ . The treatment,  $n_2$  resulted in the highest CGR and RGR at 20 DAS-40 DAS, 40 DAS-60 DAS and 60 DAS-harvest. The highest number of capsules per plant, seeds per capsule and seed yield were observed in  $n_2$ . While, haulm yield was higher in  $n_2$  and was on par with  $n_1$ . Among the quality parameters of seeds,  $n_2$  had higher content of P, Ca, Mg, Fe and Zn. Higher available N, P and K in the post-harvest soil were observed in  $n_2$  which was on par with  $n_1$ . The total uptake of nutrients (N, P and K) were also higher in  $n_2$ . The results on economics of cultivation revealed that the highest gross return, net return and B:C ratio were observed in  $n_2$ .

The growth parameters varied among different varieties of sesame. Among the varieties, the tallest plants were observed in  $v_5$  (GT 10) at 20 DAS, 40 DAS and at harvest. However, at 60 DAS,  $v_5$  was on par with  $v_4$  (Thilak). At 40 DAS, GT 10 ( $v_5$ ) resulted in the greatest number of leaves per plant. While at 60 DAS,  $v_5$  had greater leaves per plant and was on par with  $v_4$ . At 40 DAS and 60 DAS,  $v_5$  produced significantly greater number of branches per plant. At 60 DAS and harvest,  $v_5$  resulted in the highest DMP (16.46 g per plant and 19.71 g per plant, respectively). Higher LAI at 60 DAS was recorded in  $v_5$  and was on par with  $v_4$ . The highest chlorophyll content was observed in  $v_5$  at 60 DAS. The variety GT 10 had higher number of capsules per plant (84.0) and seed yield (1066.0 kg ha<sup>-1</sup>). The variety GT 10 also resulted in higher haulm yield ha<sup>-1</sup> (2502 kg ha<sup>-1</sup>) which was on par with  $v_4$  (2430 kg ha<sup>-1</sup>).

Among the varieties,  $v_5$  recorded higher P, Ca, Mg and Fe content of the seeds. The highest available N and P in the post-harvest soil were observed in  $v_5$ . While higher soil available K was observed in  $v_5$  and was on par with  $v_4$ . The variety GT 10 also resulted in the highest total N, P and K uptake. Similarly, the results on

economics revealed that the highest gross return, net return and B:C ratio were observed in GT 10.

Interaction effect of nutrient levels over varieties was found significant. At 20 DAS, 60 DAS and harvest taller plants were produced by  $n_2v_5$ . At 40 DAS, taller plants were observed in  $n_3v_5$  and was on par with  $n_1v_4$ ,  $n_2v_5$  and  $n_4v_5$ . At 40 DAS,  $n_2v_5$  recorded greater number of leaves per plant and was on par with  $n_2v_4$  and  $n_3v_5$ . However, at 60 DAS,  $n_2v_5$  recorded greater number of leaves per plant and was on par with  $n_3v_5$ ,  $n_2v_4$ ,  $n_3v_3$  and  $n_2v_1$ . At 60 DAS,  $n_2v_5$  resulted in DMP (18.63 g per plant) and was on par with  $n_2v_4$  (18.02 g per plant). However, at harvest the highest DMP was observed in  $n_2v_5$  (21.70 g per plant).

At 60 DAS, the highest LAI was observed in  $n_2v_5$ . Similarly, at 40 DAS and 60 DAS, higher chlorophyll content was observed in  $n_2v_5$ . Among the treatments,  $n_2v_5$  produced greater number of capsules per plant (100.7) and was on par with  $n_2v_4$  (100.2). The treatment  $n_2v_5$  produced higher seed yield  $ha^{-1}$  (1227.2  $kg\ ha^{-1}$ ) which was on par with  $n_2v_4$  (1165.8  $kg\ ha^{-1}$ ). Higher haulm yield  $ha^{-1}$  was observed in  $n_2v_5$  which was on par with  $n_2v_4$  and  $n_1v_5$ . Among the quality parameters, higher Mg content was observed in  $n_2v_4$  and Zn content in  $n_2v_5$ . The treatment  $n_2v_5$ , resulted in higher available N in the post-experiment soil which was on par with  $n_1v_5$ ,  $n_4v_5$ ,  $n_2v_4$ ,  $n_1v_4$ ,  $n_4v_4$  and  $n_3v_4$ . The treatment  $n_2v_5$  also resulted in higher total N and P uptake, gross return, net return and B:C ratio.

The interaction effect of varieties over nutrient levels revealed that at 60 DAS, Thilathara ( $v_2$ ), Thilak ( $v_4$ ), GT 10 ( $v_5$ ) and TMV 7 ( $v_6$ ) produced taller plants at  $n_2$ . However, Kayamkulam 1 ( $v_1$ ) and Thilarani ( $v_3$ ) produced taller plants at  $n_3$ . At harvest, all varieties produced taller plants at  $n_2$  except  $v_3$ , which produced taller plants at  $n_3$ . At 40 DAS, all varieties produced greater number of leaves per plant at  $n_2$ . While at 60 DAS, all varieties except  $v_3$  produced greater number of leaves per plant at  $n_2$ . Thilarani ( $v_3$ ) produced greater number of leaves per plant at  $n_3$ . At 60 DAS and harvest, all varieties produced higher DMP, LAI and chlorophyll content at  $n_2$ . All varieties produced the greatest number of capsules per plant and the highest seed yield  $ha^{-1}$  at  $n_2$ . Similarly, all varieties except  $v_3$  produced higher

haulm yield  $\text{ha}^{-1}$  at  $n_2$ . However,  $v_3$  produced higher haulm yield  $\text{ha}^{-1}$  at  $n_1$ . All varieties recorded higher Mg content except TMV 7 at  $n_2$ . However all varieties had higher Zn content at  $n_2$ . All varieties except Kayamkulam 1 ( $v_1$ ) recorded higher available N in post-experiment soil at  $n_2$ . While  $v_1$  recorded higher available N at  $n_1$ . All varieties resulted in higher N and P uptake at nutrient level  $n_2$ . All varieties resulted in the highest gross return, net return and B:C ratio at  $n_2$ .

The leachates of different sesame varieties had significant impact on germination and seedling growth of tested weeds *viz.*, *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*. Leachate of variety GT 10 had significant inhibitory effect on the germination of seeds of *Alternanthera sessilis* and *Setaria barbata* and tubers of *Cyperus rotundus* with a germination percentage of 16.65 per cent, 13.35 per cent and 10.00 per cent, respectively. Leachate of variety GT 10 had significant inhibitory effect on the shoot length and root length of all tested weeds. However, leachate of variety GT 10 produced lower seedling fresh weight in *Alternanthera sessilis* and was on par with Thilarani, TMV 7 and Thilathara. While, the lowest seedling fresh weight in *Setaria barbata* and *Cyperus rotundus* were observed with the application of leachate of variety GT 10. In all tested weeds, leachate of variety GT 10 resulted in the lowest seedling dry weight, SVI I and SVI II.

Similarly, the leachates of different sesame varieties had significant impact on germination and seedling growth of crop *viz.*, cowpea and okra. Application of leachate of variety GT 10 resulted in the lowest germination percentage, seedling shoot length, root length, fresh weight, dry weight, SVI I and SVI II of cowpea and okra. While leachates had no significant effect on the germination and seedling growth of amaranthus.

From the results of the study, the following findings could be concluded:

- The optimum dose NPK dose for sesame under partial shade of coconut in Southern Laterites was  $34:21:3 \text{ kg ha}^{-1}$ .
- Among the six test varieties of sesame, GT 10 was identified as the best suitable variety for Southern Laterites.

- The variety GT 10 raised under partial shade of coconut gardens manured with 5 t ha<sup>-1</sup> of FYM + 34:21:3 kg NPK ha<sup>-1</sup> (full dose of P, K and 75 per cent N as basal application and 25 per cent N as foliar spray at 3 per cent concentration, 30 DAS) realized the highest seed yield, net return and B:C ratio.
- Adoption of this optimum dose (34:21:3 kg NPK ha<sup>-1</sup>) could reduce the consumption of 90 per cent K, compared to KAU POP recommendation, as the soil in Southern Laterites have medium to high K.
- Application of leachate of variety GT 10 had significant inhibitory effect on the germination and growth of *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*.
- Similarly, leachate of variety GT 10 had significant inhibitory effect on the germination and growth of cowpea and okra.

#### FUTURE LINE OF WORK

- Validation of the results in coconut plantations at different locations of Southern Laterites.
- Assess the residual effect of sesame on other intercrops in coconut.
- Field level assessment of the allelopathic potential of sesame varieties.

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# **APPENDICES**

## APPENDIX I

Weather parameters during cropping period (December 2021 to March 2021)

Standard week	Temperature ( <sup>0</sup> C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
51	32.4	24.2	87.0	0
52	31.7	21.7	88.2	0.3
1	32.4	22.0	84.6	9
2	31.9	24.0	87.3	0
3	32.5	24.2	85.6	0
4	32.3	22.1	87.8	0
5	32.8	20.9	83.6	0
6	32.8	21.5	83.6	0
7	32.2	21.4	85.6	57.4
8	32.2	21.5	84.1	16.4
9	32.5	22.1	84.1	0.8
10	32.7	23.3	84.8	0
11	33.4	24.2	81.9	0
12	33.9	25.1	82.4	0

## APPENDIX II

Weather parameters during cropping period (September 2022 to January 2023)

Standard week	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
40	31.7	24.0	85.4	8.0
41	32.2	24.0	87.6	3.2
42	30.7	23.6	91.9	179.7
43	30.5	23.0	88.0	54.6
44	30.9	23.2	84.4	80.2
45	31.1	23.0	85.8	69.5
46	30.6	23.2	86.8	25.3
47	30.6	22.4	83.9	3.2
48	31.8	21.1	80.4	0
49	31.2	21.1	85.1	27.4
50	29.7	21.4	85.2	41.2
51	31.7	20.9	83.1	1.7
52	31.7	21.1	86.7	27.3
1	31.6	20.9	81.1	0

### APPENDIX III

Weather parameters during cropping period (August 2024 to November 2024)

Standard week	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
34	32.7	24.0	85.4	0
35	32.2	24.0	87.6	0.3
36	31.7	23.4	88.9	4
37	30.8	23.0	88.0	0
38	30.9	23.2	84.4	0
39	31.0	23.0	83.2	0
40	30.6	23.2	85.8	0
41	32.6	22.4	79.9	0
42	31.7	21.1	80.4	17.4
43	31.2	21.1	84.1	10.4
44	30.7	22.4	82.4	0.8
45	31.9	21.9	79.6	0
46	31.8	21.1	82.2	0
47	32.6	24.2	79.1	0

## APPENDIX IV

### Cost of cultivation of experiment I

<b>Treatments</b>	<b>Cost of cultivation (₹ ha<sup>-1</sup>)</b>
T <sub>1</sub>	30970
T <sub>2</sub>	31234
T <sub>3</sub>	31420
T <sub>4</sub>	31684
T <sub>5</sub>	31276
T <sub>6</sub>	31540
T <sub>7</sub>	31726
T <sub>8</sub>	31990
T <sub>9</sub>	31260
T <sub>10</sub>	31700
T <sub>11</sub>	31109
T <sub>12</sub>	31860
T <sub>13</sub>	31229
T <sub>14</sub>	31739
T <sub>15</sub>	31484

## APPENDIX V

### Cost of cultivation of experiment II

<b>Treatments</b>	<b>Cost of cultivation (₹ ha<sup>-1</sup>)</b>
n <sub>1</sub> V <sub>1</sub>	33924
n <sub>1</sub> V <sub>2</sub>	33924
n <sub>1</sub> V <sub>3</sub>	33924
n <sub>1</sub> V <sub>4</sub>	33924
n <sub>1</sub> V <sub>5</sub>	33924
n <sub>1</sub> V <sub>6</sub>	33924
n <sub>2</sub> V <sub>1</sub>	37883
n <sub>2</sub> V <sub>2</sub>	37883
n <sub>2</sub> V <sub>3</sub>	37883
n <sub>2</sub> V <sub>4</sub>	37883
n <sub>2</sub> V <sub>5</sub>	37883
n <sub>2</sub> V <sub>6</sub>	37883
n <sub>3</sub> V <sub>1</sub>	33983
n <sub>3</sub> V <sub>2</sub>	33983
n <sub>3</sub> V <sub>3</sub>	33983
n <sub>3</sub> V <sub>4</sub>	33983
n <sub>3</sub> V <sub>5</sub>	33983
n <sub>3</sub> V <sub>6</sub>	33983
n <sub>4</sub> V <sub>1</sub>	33970
n <sub>4</sub> V <sub>2</sub>	33970
n <sub>4</sub> V <sub>3</sub>	33970
n <sub>4</sub> V <sub>4</sub>	33970
n <sub>4</sub> V <sub>5</sub>	33970
n <sub>4</sub> V <sub>6</sub>	33970
n <sub>5</sub> V <sub>1</sub>	34125
n <sub>5</sub> V <sub>2</sub>	34125
n <sub>5</sub> V <sub>3</sub>	34125
n <sub>5</sub> V <sub>4</sub>	34125
n <sub>5</sub> V <sub>5</sub>	34125
n <sub>5</sub> V <sub>6</sub>	34125

## APPENDIX VI

### Cost of inputs

Inputs	Cost (₹)
Urea	8 kg <sup>-1</sup>
Rajphos	10 kg <sup>-1</sup>
MOP	17 kg <sup>-1</sup>
FYM	2 kg <sup>-1</sup>
Sesame seeds	80 kg <sup>-1</sup>
Labour wage (Men)	1000 d <sup>-1</sup>
Labour wage (Women)	800 d <sup>-1</sup>

**AGRO-TECHNIQUES FOR SESAME (*Sesamum indicum* L.)  
UNDER PARTIAL SHADE OF COCONUT IN  
SOUTHERN LATERITES**

*by*

**ARUNIMA BABU C S  
(2020-21-031)**

**ABSTRACT  
of the thesis submitted in partial fulfillment of the  
requirement for the degree of**

**DOCTOR OF PHILOSOPHY IN AGRICULTURE**

**Faculty of Agriculture  
Kerala Agricultural University**



**DEPARTMENT OF AGRONOMY  
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## ABSTRACT

The study entitled ‘Agro-techniques for sesame (*Sesamum indicum* L.) under partial shade of coconut in Southern Laterites’ was undertaken at College of Agriculture, Vellayani during 2021-24, with the objectives to standardize the nutrient levels for sesame under partial shade of coconut in Southern Laterites, assess the response of promising sesame varieties to the identified optimum nutrient levels and evaluate the allelopathic effect of sesame on selected weeds and crops.

Field experiments were conducted at Coconut Research Station (CRS), Balaramapuram, to identify the optimum nutrient levels for sesame in Southern Laterites during *Rabi* 2021-22 and 2022-23, using variety Thilak. The experiments were conducted in the inter row spaces of coconut palms aged more than 60 years planted at a spacing of 7.6 m × 7.6 m. It was laid out in central composite design (CCD), with 20 runs *viz.*, T<sub>1</sub>:31:20:16 kg NPK ha<sup>-1</sup>, T<sub>2</sub>:64:20:16 kg NPK ha<sup>-1</sup>, T<sub>3</sub>:31:50:16 kg NPK ha<sup>-1</sup>, T<sub>4</sub>:64:50:16 kg NPK ha<sup>-1</sup>, T<sub>5</sub>:31:20:34 kg NPK ha<sup>-1</sup>, T<sub>6</sub>:64:20:34 kg NPK ha<sup>-1</sup>, T<sub>7</sub>:31:50:34 kg NPK ha<sup>-1</sup>, T<sub>8</sub>:64:50:34 kg NPK ha<sup>-1</sup>, T<sub>9</sub>:20:35:25 kg NPK ha<sup>-1</sup>, T<sub>10</sub>:75:35:25 kg NPK ha<sup>-1</sup>, T<sub>11</sub>:48:10:25 kg NPK ha<sup>-1</sup>, T<sub>12</sub>:48:60:25 kg NPK ha<sup>-1</sup>, T<sub>13</sub>:48:35:10 kg NPK ha<sup>-1</sup>, T<sub>14</sub>:48:35:40 kg NPK ha<sup>-1</sup> and T<sub>15</sub> to T<sub>20</sub> (represented the central points of CCD): 48:35:25 kg NPK ha<sup>-1</sup>, replicated thrice. The nutrient level for sesame in Southern Laterites was standardized by plotting response surface curves using the seed yield of sesame during both years. Remaining observations were statistically analysed using randomized block design (RBD) with fifteen treatments (T<sub>1</sub>-T<sub>14</sub>, same as that of CCD, T<sub>15</sub>: was taken as the average of treatments T<sub>15</sub>-T<sub>20</sub> in CCD).

The growth parameters *viz.*, plant height, number of leaves per plant, number of branches per plant and dry matter production were significantly influenced by different nutrient levels. Results on growth attributes at harvest revealed that, T<sub>1</sub> produced taller plants during 2021-22 and 2022-23. However, T<sub>1</sub> was on par with T<sub>2</sub> during 2021-22 and with T<sub>2</sub> and T<sub>4</sub> during 2022-23. During both years, the highest number of leaves per plant was observed in T<sub>1</sub> at 60 DAS. However, T<sub>1</sub> resulted in more number of branches per plant at harvest during 2021-

22 and was on par with T<sub>2</sub>. While, during 2022-23, T<sub>2</sub> produced more number of branches per plant and was on par with T<sub>1</sub>. During both years, DMP was significantly higher in T<sub>1</sub> at all stages of observation. Physiological parameters were also significantly influenced by nutrient levels. During both years at 60 DAS, T<sub>1</sub> resulted in higher LAI. However, it was on par with T<sub>2</sub> and T<sub>4</sub>, during 2021-22 and with T<sub>2</sub> during 2022-23. Chlorophyll content at 60 DAS was significant only during 2021-22 and T<sub>2</sub> resulted in higher chlorophyll content which was on par with T<sub>1</sub> and T<sub>4</sub>. Crop growth rate varied significantly with nutrient levels. At 40 DAS-60 DAS, T<sub>1</sub> resulted in higher CGR which was on par with T<sub>2</sub>, T<sub>4</sub> and T<sub>7</sub> during both years. Similarly, higher RGR was noted in T<sub>1</sub> which was on par with T<sub>2</sub>, T<sub>4</sub>, T<sub>7</sub> and T<sub>11</sub> at 40 DAS-60 DAS.

Greater number of seeds per capsule was observed in T<sub>1</sub> which was on par with T<sub>2</sub> during 2021-22 and with T<sub>2</sub> and T<sub>4</sub> during 2022-23. During both years, the highest number of capsules per plant (57.7 and 74.7, respectively) and seed yield (503.5 kg ha<sup>-1</sup> and 554.7 kg ha<sup>-1</sup>, respectively) were observed in T<sub>1</sub>. Pooled analysis of seed yield also revealed the highest value in T<sub>1</sub> (529.1 kg ha<sup>-1</sup>). Whereas, the haulm yield and harvest index in T<sub>1</sub> and T<sub>2</sub> were comparable during both years.

The optimum NPK levels identified by plotting the response surface curves during 2021-22 were 35:26:7 kg NPK ha<sup>-1</sup> and 34:21:3 kg NPK ha<sup>-1</sup> and during 2022-23 was 34:35:3 kg NPK ha<sup>-1</sup>.

Oil content in seed varied significantly only during 2021-22 with the treatment T<sub>1</sub> resulting in significantly higher oil content. During 2021-22, higher crude protein content was observed in T<sub>1</sub> which was on par with T<sub>2</sub>. While during 2022-23, T<sub>2</sub> resulted in higher crude protein content which was on par with T<sub>1</sub> and T<sub>4</sub>. Higher P, Mg and Fe content in the seeds were observed in T<sub>2</sub> during both years. Calcium content in the seeds was significant only during 2022-23 and was higher in T<sub>1</sub>. Similarly, Zinc content in the seeds was significant only during 2021-22 and was higher in T<sub>1</sub>.

Post experiment soil analysis revealed that T<sub>1</sub> resulted in higher organic carbon content, available N and P in the soil during both years. Available K was

higher in T<sub>1</sub> during 2021-22 and in T<sub>2</sub> during 2022-23. The N, P and K uptake by the crop were also significantly influenced by nutrient levels and were higher in T<sub>1</sub>.

The results on economics of cultivation revealed the highest gross return, net return and B:C ratio in T<sub>1</sub> during both years.

Field experiment to validate the response of promising sesame varieties to the identified optimum nutrient levels was laid out in split plot design during 2023-24 at CRS Balaramapuram. The main plot treatments included five nutrient levels *viz.*, 35:26:7 kg NPK ha<sup>-1</sup> (n<sub>1</sub>), 34:21:3 kg NPK ha<sup>-1</sup> (n<sub>2</sub>), 34:35:3 kg NPK ha<sup>-1</sup> (n<sub>3</sub>), 31:20:16 kg NPK ha<sup>-1</sup> (n<sub>4</sub>) and 30:15:30 kg NPK ha<sup>-1</sup> (n<sub>5</sub>) and the sub plot treatments comprised of six sesame varieties *viz.*, Kayamkulam 1(v<sub>1</sub>), Thilathara (v<sub>2</sub>), Thilarani (v<sub>3</sub>), Thilak (v<sub>4</sub>), GT 10 (v<sub>5</sub>) and TMV 7(v<sub>6</sub>).

The nutrient levels had significant influence on growth parameters. Among the nutrient levels, n<sub>2</sub> produced the tallest plants at harvest. Similarly at 60 DAS, number of leaves and branches per plant were higher in n<sub>2</sub>. At harvest significantly higher DMP was observed in n<sub>2</sub>. Similarly at 60 DAS, n<sub>2</sub> resulted in higher LAI and chlorophyll content which was on par with n<sub>1</sub>. At 60 DAS-harvest, n<sub>2</sub> resulted in the highest CGR and RGR. Significantly more number of capsules per plant, seeds per capsule and higher seed yield were observed in n<sub>2</sub>. Higher haulm yield was also observed in n<sub>2</sub> which was on par with n<sub>1</sub>. Among the quality parameters, higher P, Ca, Mg, Fe and Zn content in the seeds were observed in n<sub>2</sub>. Similarly, higher N, P and K uptake and available N, P and K in the soil were observed in n<sub>2</sub>. The results on economics of cultivation revealed that the highest gross return, net return and B:C ratio were observed in n<sub>2</sub>. Adoption of optimum nutrient level (34:21:3 kg NPK ha<sup>-1</sup>) reduced the consumption of K by 90 per cent, compared to KAU POP recommendation, which could be attributed to medium to high K status in the soil of Southern Laterites.

The growth parameters varied among the tested sesame varieties. Among the varieties, the tallest plants were observed in v<sub>5</sub> at harvest. At 60 DAS, greater number of leaves and branches per plant were recorded in v<sub>5</sub> which was on par with v<sub>4</sub>. At harvest, the highest DMP was observed in v<sub>5</sub> (19.71 g per plant). Similarly, at 60 DAS, v<sub>5</sub> had higher LAI which was on par with v<sub>4</sub>. The chlorophyll content

was the highest in v<sub>5</sub> at 60 DAS. Significantly more number of capsules per plant (84.0), higher seed yield (1066.0 kg ha<sup>-1</sup>) and haulm yield (2502 kg ha<sup>-1</sup>) were recorded in v<sub>5</sub>. The variety v<sub>5</sub> recorded higher P, Ca, Mg and Fe content in the seeds. Results on nutrient uptake and availability revealed that higher soil available N, P and K in the post-harvest soil and N, P and K uptake by the crop were observed in v<sub>5</sub>. The variety GT 10 resulted in the highest gross return, net return and B:C ratio.

Interaction effect of nutrient levels over varieties revealed that at 60 DAS and harvest, taller plants were observed in n<sub>2</sub>v<sub>5</sub>. The treatment, n<sub>2</sub>v<sub>5</sub> also recorded more number of leaves per plant at 60 DAS. At harvest, the highest DMP was observed in n<sub>2</sub>v<sub>5</sub>. Higher LAI and chlorophyll content at 60 DAS were observed in n<sub>2</sub>v<sub>5</sub>. Similarly, n<sub>2</sub>v<sub>5</sub> produced greater number of capsules per plant, higher seed yield ha<sup>-1</sup> and haulm yield ha<sup>-1</sup>. The results on nutrient uptake revealed that n<sub>2</sub>v<sub>5</sub> resulted in higher N and P uptake. The treatment n<sub>2</sub>v<sub>5</sub> also resulted in the highest gross return, net return and B:C ratio.

The interaction effect of varieties over nutrient levels revealed that at harvest, all varieties except v<sub>3</sub> produced taller plants at nutrient level n<sub>2</sub>. While v<sub>3</sub> produced taller plants at n<sub>3</sub>. At 60 DAS, all varieties except v<sub>3</sub>, produced greater number of leaves per plant at n<sub>2</sub>. While, v<sub>3</sub> produced higher number of leaves per plant at n<sub>3</sub>. At 60 DAS and harvest, all varieties produced higher DMP, LAI and chlorophyll content at n<sub>2</sub>. Similarly, all varieties produced the highest number of capsules per plant and seed yield ha<sup>-1</sup> at n<sub>2</sub>. All varieties except v<sub>3</sub> produced higher haulm yield ha<sup>-1</sup> at n<sub>2</sub>. However, v<sub>3</sub> produced higher haulm yield ha<sup>-1</sup> at n<sub>1</sub>. The results on post experiment soil analysis revealed that all varieties except v<sub>1</sub> recorded higher available N at n<sub>2</sub>. While, v<sub>1</sub> recorded higher available N at n<sub>1</sub>. All varieties recorded the highest N and P uptake at nutrient level n<sub>2</sub>. The results on economics of cultivation revealed that all varieties recorded the highest gross return, net return and B:C ratio at n<sub>2</sub>.

The leachates of different sesame varieties had significant impact on germination and seedling growth of weeds viz., *Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*. Leachate of variety GT10 had significant inhibitory

effect on the germination, seedling shoot length, root length, dry weight, SVI I and SVI II of all tested weeds. Similarly, the leachates of different sesame varieties had significant impact on germination and seedling growth of tested crops *viz.*, cowpea and okra. Application of leachate of variety GT 10 resulted in the lowest germination percentage, seedling shoot length, root length, fresh weight, dry weight, SVI I and SVI II of cowpea and okra. While leachates had no significant effect on the germination and seedling growth of amaranthus.

From the results of the study, it could be concluded that the optimum nutrient level for sesame under partial shade of coconut in Southern Laterites was 34:21:3 kg NPK ha<sup>-1</sup>. Among the tested sesame varieties, GT 10 was identified as the best variety for Southern Laterites. The variety GT 10 raised under partial shade of coconut gardens manured with 5 t ha<sup>-1</sup> of FYM + 34:21:3 kg NPK ha<sup>-1</sup> (full dose of P, K and 75 per cent N as basal application and 25 per cent N as foliar spray at 3 per cent concentration, 30 DAS) realized the highest seed yield, net return and B:C ratio. Application of leachate of variety GT 10 had significant inhibitory effect on the germination and growth of test weeds (*Alternanthera sessilis*, *Setaria barbata* and *Cyperus rotundus*) and test crops (cowpea and okra).

## സംഗ്രഹം

ദക്ഷിണ ചെങ്കൽ മണ്ണ് പ്രദേശങ്ങളിൽ, തെങ്ങിന്റെ ഭാഗിക തണലിൽ ഇടവിളയായി കൃഷി ചെയ്യുന്ന, എള്ളിന്റെ കാർഷികസാങ്കേതിക വിദ്യകൾ എന്ന വിഷയത്തെ ആസ്പദമാക്കി 2021-24 കാലയളവിൽ വെള്ളായണി കാർഷിക കോളേജിൽ പഠനം നടത്തുകയുണ്ടായി. എള്ളിന്റെ വളപ്രയോഗം ക്രമീകരിക്കുക, മികച്ച വളപ്രയോഗങ്ങളോട് എള്ളിനങ്ങളുടെ പ്രതികരണം വിലയിരുത്തുക, തിരഞ്ഞെടുത്ത വിളകളിലും, കളകളിലും എള്ളിന്റെ അല്ലെലോപ്പതിക് പ്രഭാവം വിലയിരുത്തുക എന്നിവയായിരുന്നു പഠനത്തിന്റെ പ്രധാന ലക്ഷ്യങ്ങൾ.

തിരുവനന്തപുരം ജില്ലയിൽ, ബാലരാമപുരത്തു സ്ഥിതി ചെയ്യുന്ന നാളികേര ഗവേഷണ കേന്ദ്രത്തിൽ വെച്ച്, റാബി 2021-22 ലും 2022-23 ലും, എള്ളിനു അനുയോജ്യമായ വളപ്രയോഗം കണ്ടെത്തുന്നതിനായി ഒന്നാം ഘട്ട പരീക്ഷണങ്ങൾ നടത്തുകയുണ്ടായി. സെൻട്രൽ കോംപോസിറ്റ് ഡിസൈൻ എന്ന പഠന രീതിയാണ് ഇതിനായി അവലംബിച്ചത്. ഇരുപത് റൺസ് (T<sub>1</sub>:31:20:16 kg NPK ha<sup>-1</sup>, T<sub>2</sub>:64:20:16 kg NPK ha<sup>-1</sup>, T<sub>3</sub>:31:50:16 kg NPK ha<sup>-1</sup>, T<sub>4</sub>:64:50:16 kg NPK ha<sup>-1</sup>, T<sub>5</sub>:31:20:34 kg NPK ha<sup>-1</sup>, T<sub>6</sub>:64:20:34 kg NPK ha<sup>-1</sup>, T<sub>7</sub>:31:50:34 kg NPK ha<sup>-1</sup>, T<sub>8</sub>:64:50:34 kg NPK ha<sup>-1</sup>, T<sub>9</sub>:20:35:25 kg NPK ha<sup>-1</sup>, T<sub>10</sub>:75:35:25 kg NPK ha<sup>-1</sup>, T<sub>11</sub>:48:10:25 kg NPK ha<sup>-1</sup>, T<sub>12</sub>:48:60:25 kg NPK ha<sup>-1</sup>, T<sub>13</sub>:48:35:10 kg NPK ha<sup>-1</sup>, T<sub>14</sub>:48:35:40 kg NPK ha<sup>-1</sup> T<sub>15</sub> മുതൽ T<sub>20</sub> വരെ 48:35:25 kg NPK ha<sup>-1</sup>) 3 റെപ്ലിക്കേഷനിലായാണ് ഉൾപ്പെടുത്തിയത്. തിലക് എന്ന എള്ളിനമാണ് ഈ പഠനത്തിനായി ഉപയോഗിച്ചത്.

ഓരോ ട്രീറ്റ്‌മെന്റുകളിലെ വിത്ത് വിളവുകളിൽ നിന്നും റെസ്‌പോൺസ് സർഫേസ് മെത്തോഡോളജി ഉപയോഗിച്ചാണ് മികച്ച വളപ്രയോഗം കണ്ടെത്തിയത്. ഇതിന്റെ അടിസ്ഥാനത്തിൽ 2021-22 ൽ, 35:26:7 kg NPK ha<sup>-1</sup> ഉം 34:21:3 kg NPK

ha<sup>-1</sup> ഉം, 2022-23 ൽ 34:35:3 kg NPK ha<sup>-1</sup> ഉം ഏറ്റവും അനുകൂലമായ വളപ്രയോഗമായി കണ്ടെത്തി. മറ്റെല്ലാ നീരിക്ഷണങ്ങളും ആർ ബി ഡി എന്ന സ്റ്റാറ്റിസ്റ്റിക്കൽ ഡിസൈൻ ഉപയോഗിച്ച് രേഖപ്പെടുത്തുകയും 31:20:16 kg NPK ha<sup>-1</sup> മികച്ച വളപ്രയോഗമായി കണ്ടെത്തുകയും ചെയ്തു.

ഒന്നാം ഘട്ട പരീക്ഷണത്തിൽ നിന്നും മികച്ച വളപ്രയോഗം കണ്ടെത്തുന്നതിനായി രണ്ടാം ഘട്ട പരീക്ഷണം നടത്തുകയുണ്ടായി. സ്പ്ലിറ്റ് പ്ലോട്ട് ഡിസൈൻ ആണ് ഇതിനായി ഉപയോഗിച്ചത്. മെയിൻ പ്ലോട്ടിൽ 5 വളപ്രയോഗങ്ങളും [35:26:7 kg NPK ha<sup>-1</sup>, 34:21:3 kg NPK ha<sup>-1</sup>, 34:35:3 kg NPK ha<sup>-1</sup> 31:20:16 kg NPK ha<sup>-1</sup>, 30:15:30 kg NPK ha<sup>-1</sup> (കേരളത്തിൽ എള്ളിന്റെ വളപ്രയോഗത്തിന്റെ അളവ്)] സബ് പ്ലോട്ടിൽ 6 എള്ളിനങ്ങളുമാണ് (കായംകുളം 1, തിലതാര, തിലറാണി, തിലക്, ജിറ്റി 10, റ്റിഎംവി 7) ഉണ്ടായിരുന്നത്. വളർച്ചയുടെയും, വിളവിന്റെയും, ഗുണനിലവാരത്തിന്റെയും, വരുമാനത്തിന്റെയും അടിസ്ഥാനത്തിൽ ജി റ്റി 10 മികച്ച എള്ളിനമായും, 34:21:3 kg NPK ha<sup>-1</sup> മികച്ച പോഷകക്രമമായും കണ്ടെത്തപ്പെട്ടു.

അല്ലെലോപ്പതിക് പഠനത്തിൽ നിന്നും വ്യത്യസ്ത എള്ളി ഇനങ്ങളുടെ ലീച്ചേറ്റുകൾക്ക് ആൾട്ടർനാൻതെറ സെസിലിസ്, സെറ്റേറിയ ബാർബെറ്റാ, സൈപ്പറസ് റോട്ടണ്ടസ് എന്നീ കളകളുടെയും (1:5 w/v) പയർ, വെണ്ട എന്നീ വിളകളുടെയും (1:10 w/v) അങ്കുരണ ശേഷിയെയും, തൈകളുടെ വളർച്ചയെയും കാര്യമായ സ്വാധീനിക്കാൻ ശേഷിയുള്ളതായി കണ്ടെത്തി. വിവിധ ലീച്ചേറ്റുകളിൽ നിന്നും ജി റ്റി 10 എന്ന എള്ളിനത്തിനാണു ഏറ്റവും കൂടുതൽ ഇൻഹിബിറ്ററി എഫക്ട് ഉള്ളതായി രേഖപ്പെടുത്തിയത്.

മേൽ പറഞ്ഞ ഗവേഷണങ്ങൾ നിന്നും ദക്ഷിണ ചെങ്കൽ മേഖലയിൽ എള്ളിനു ഏറ്റവും മികച്ച വിളവ് ലഭിക്കുന്നതിനായി  $5 \text{ t ha}^{-1}$  FYM +  $34:21:3 \text{ kg NPK ha}^{-1}$  (75 % N അടിവളമായും, 25 % N, നട്ടു കഴിഞ്ഞു 30 ദിവസങ്ങൾക്ക് ശേഷം ഇലകളിൽ 3% സ്പ്രേ) ഏറ്റവും ഉത്തമമായ വളപ്രയോഗമായി കണ്ടെത്തി. കൂടാതെ ജി റ്റി 10 മികച്ച എള്ളിനമായും കണ്ടെത്തി. ജി റ്റി 10 എന്ന എള്ളിനത്തിൽ നിന്നും തയ്യാറാക്കിയ ലീച്ചേറ്റുകൾ പരീക്ഷണത്തിനായി ഉപയോഗിച്ച കളകളുടേയും വിളകളുടേയും അങ്കുരണ ശേഷിയേയും വളർച്ചയേയും പ്രതികൂലമായി ബാധിക്കുന്നതായി കണ്ടെത്തി.