Maximizing Black Grain Yield Through Nutrient and Growth Regulator Management

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Abstract

Originating in India and Central Asia, black gramme (Vigna mungo (L.) Hepper) is a well-known and historic leguminous crop in Asia. Due to its rapid growth and minimal fertiliser needs, black gramme is widely grown in Tamil Nadu as a rice fallow pulse crop. Its goal is to make use of the rice's natural nutrients and moisture after all other fertilisers have been removed.

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1. Introduction

In countries where vegetarianism is the norm, pulses—also known as "Poor man's meat" and "rich man's vegetable"—are an essential food group. Protein content in pulses is around 20-40%, which is double or triples that of cereals. India is the world's greatest producer, user, and importer of pulses, yet the nation still doesn't have enough to meet its need. Globally, pulses are grown on 68.3 million ha of land and harvest 57.5 million metric tonnes. Indian agriculture relies heavily on pulse crops, and the country is the world's biggest producer of pulses. India has a total of around 25.23 million hectares dedicated to growing pulses, yielding 19.27 million metric tonnes at a productivity of 764 kilogrammes per hectare. [1]

By 2030, it is expected that 32 million metric tonnes of pulses would be needed to meet the country's need for food security. Despite the fact that pulses are high-protein crops, more than 78% of the world's supply is dedicated to growing them. As a result, India's production for these crops is much lower than the global average. India has made great strides in the production of other crops since the introduction of five year plans, but the output and productivity of pulses have remained mostly unchanged. As a consequence, the amount of pulses available in India has dropped from 60 g per day per person in 1951 to 41.7 g per day per person in 2016, despite the fact that ICMR advises 80 g per day per person. [2-3]

Originating in India and Central Asia, black gramme is a well-known and historic leguminous crop across Asia. It is the third most widely grown pulse in the country of India. Black gramme is a very important and readily digested source of protein (24%), fat (1.3%), calcium (124 mg), phosphorus (326 mg), iron (7.3 mg), and vitamin B, and its significance to the Indian economy

cannot be overstated. As a rice fallow pulse crop, black gramme is widely grown in Tamil Nadu due to its short duration and low fertilisers demand.[4-6]

The average productivity of black gramme farms in Tamil Nadu is 851 kilogrammes per hectare per year, yielding 3.10 million tonnes of crop in 2013. For centuries, farmers in the delta regions of Tamil Nadu have used utera to harvest black gramme during the rice harvest's fallow period. The goal is to make use of the water and nutrients already present in the rice, so no additional fertilisers are used. As a result, rice fallow pulse production is only 250 kg ha-1. The lack of food has dangerous health consequences.[7-8]

In recent years, India's average black gramme crop productivity has rather remained static at 343 kg ha-1 for a number of reasons, including a dearth of modern varieties, a lack of suitable seed production techniques, cultural practises, inefficient harvesting and post-harvesting procedures, poor storage management, and so on. In most cases, the production of pulse crops falls well short of its potential.[9-10]

2. Material And Methods

Black gramme production was optimised by nutrition and growth regulator control through laboratory and field tests.

Laboratory experiments

1. Germination, growth, and chlorophyll concentration in black gramme seedlings as a function of pre-soak time

For this experiment, we used black gramme seeds that were typical in terms of size, colour, and weight. The seeds were germinated in various solution concentrations according to treatment and the resulting plants were compared to those that had just received regular tap water for irrigation as a control. After being exposed to mercuric chloride (HgCl2) at a concentration of 0.2% for two minutes, the black gramme seeds were rinsed extensively. Black gramme seed weights were measured out at 200g per treatment. The seeds were measured out and placed in a plastic container with a 500 cc capacity, then treated with KCl and micronutrient fertilisers. For 24 hours, the seeds were submerged in a nutritional solution. For 7 days at room temperature (28+2 0C), the 25 soaking seeds were evenly spaced on each germination paper to sprout. Sixteen independent treatments and controls were conducted in CRD. Germination percentage, root length, shoot length, dry matter output, and vigour index were measured as indicators of seed quality.

2. Black gramme seed germination, plant height, and chlorophyll content after pelletization

Each treatment's 200 g of black gramme seeds were measured into a plastic bowl with a 500 ml capacity. DAP and KCl fertilisers were added at the appropriate rates for 200 g of seed pellets. To ensure that 200 g-1 of seeds had access to the necessary micronutrients, the fertilisers were

dissolved in water and supplied at a rate of 20 ml of nutrient solutions. The seed was coated with a fertiliser mixture, and then 30 cc of maida gruel was added to preserve the coating. After 24 hours in the shade, 25 seeds were evenly spaced on germination paper and given 7 days at room temperature (28+2 0C) to germinate and produce seedlings. Sixteen independent treatments and controls were conducted in CRD. Root length, shoot length, and germination rate were only some of the morphological characteristics measured from randomly chosen seedlings across replicates. Shoots and roots were transplanted separately from the black gramme seeds. Germination percentage, root length, shoot length, dry matter output, and vigour index were measured as indicators of seed quality.

Field experiments

Annamalai University's Experimental Farm at Annamalainagar, Cuddalore district, Tamil Nadu, India (11°24'N Latitude, 79°41'E Longitude, +5.79 m Above Mean Sea Level) was the site of the outdoor trials.

Annamalainagar has a warm, humid climate with scorching summers and mild winters. The average high was 29.8 degrees Celsius, the average low was 18.6 degrees Celsius, and the average rainfall was 1500 millimetres, with 1000 millimetres falling during the north-east monsoon (October to December), 400 millimetres falling during the south-west monsoon (June to September), and 100 millimetres falling as summer showers. Annexure I includes meteorological information for the crop months of January–April in 2018, 2019, 2020, and 2021.

The soil has the texture of clay loam, the nutrient composition of (Kondal series - Typic Haplusterts), and the chemical composition of (low KMnO4-N, medium Olsen-P, and high NH4OAc-K). Table provides information on the soils' physicochemical characteristics.

The fieldwork was place during the months of January and April in 2018, 2019, 2020, and 2021. As a trial, we planted a crop of black gramme (variety ADT 3) in rice fallow for a total of 70 days. Table lists several ADT-3 black gramme varietal characteristics. The experimental plot has a background in the traditional rice-rice-pulse cropping pattern of the area. The N: P2O5: K2O kg ha-1 ratio for Kharif rice was 120: 40: 40, whereas for Rabi rice it was 150: 50: 50.

Remarks Relating To Biometrics

Five plants were selected at random from each plot and labelled. All biometric observations were recorded at various phases of crop development using these tagged plants. Here are some of the biometric data that was collected.

- **Growth parameters**

1. Plant height

On days 30 and 45, as well as during harvest, we measured the height of the plants from the ground up to the highest leaf.

2. Leaf area index (LAI)

The leaf area index was calculated at 30 and 45 DAS.

Leaf area = LxBxK

Where,

L = maximum leaf length in centimetres

B = maximum leaf ventilation in cm

K =Error-correcting factor of 0.7

The following formula was used to get LAI from this data.LAI = $\frac{\text{Leaf area per unit land area } (cm^2)}{\text{Unit land area } (cm^2)}$

3. Chlorophyll content

At 30 and 45 days after emergence, the chlorophyll content of the leaves was determined.

$$\text{Chll 'a' (mg g}^{-1}) = \frac{12.7 \text{ x A663} - 2.69 \text{ x A645}}{\text{A x 1000 x Sample weight}} \text{ x v}$$

$$\text{Chll 'b' (mg g}^{-1}) = \frac{22.9\text{x A645} - 4.68\text{x A663}}{\text{A x1000x Sampleweight}} \text{ x v}$$

$$\text{Total chlorophyll} = \text{Chll 'a'} + \text{Chll 'b'}$$

Where

A = light travel distance in cm (=1)

V = the extract's total volume

4. Dry matter production (DMP)

On days 30 and 45 DAS, we randomly selected five plants from each plot to be shade-dried. The samples were dried in a 70 degree oven for 48 hours. The weights and measurements of the oven-dried plant samples were recorded. Calculated DMP was reported in units of kg ha-1.

Taking Samples Of Land And Plants For Testing

- **Analysing Samples of Soil**

After each crop was harvested, soil samples were taken from each treatment plot in each replication. Each replicate was air dried, powdered, and sieved through a 2 mm sieve to create a composite sample for nutritional analysis. Estimation strategies based on analytical procedures are detailed in table.

- **Sampling and analyzing plants**

At harvest, independent samples of plants were taken from each of the replicated treatments. To ensure as much dirt was removed as possible, the plants were chopped down to the earth's surface before being rinsed in tap water, 0.1 N HCl, and distilled water. After being cleaned, the plants were air dried for 24 hours before being baked at 70 degrees Celsius for 48 hours. After sorting, weighing, and powdering the haulm and pods individually in the Wiley mill, the results were analysed. The NPK and micronutrient content of the powdered haulm and seeds were analysed, and the absorption of the appropriate nutrients was calculated. Table summarises the data analysis techniques that were used.

Uptake of Nutrients

The following formula was used to determine nutritional intake:

$$\text{Nutrient uptake} = \frac{\text{Nutrient content \%}}{100} \text{ x DMP (Grain/Haulm)}$$

Statistical Analysis

Statistical analysis was applied to the collected soil and plant analytical data, yield, and yield components in accordance with the established protocol.

Table 1: Specifics of Soil Analytical Procedures

S. No.	Determination	Methodology
A.	**Physical properties**	
1.	Textural fractions	International pipette method
2.	Bulk density and pore space	Measuring cylinder method
B.	**Physico-chemical properties**	
3.	Soil reaction (pH)	Potentiometric method (1:2.5 soil: water extract)
4.	Electrical conductivity (EC)	Conductometric method (1:2.5 soil: water extract)
5.	Cation exchange	Neutral normal ammonium acetate extraction

	capacity (CEC)	method
C.	**Chemical properties**	
6.	Organic carbon	Chromic acid wet digestion method
7.	$KMnO_4$-N	Alkaline permanganate method
8.	Olsen-P	Ascorbic acid modification of the molybdate blue colour method (0.5 M $NaHCO_3$, pH 8.5)
9.	NH_4OAC-K	Neutral normal ammonium acetate extraction (Neutral normal ammonium acetate) by flame photometer method
10.	Available B (Hot water soluble)	Azomethine H method

Table 2: Methodology specifics for plant analysis

Determination	Methodology
Nitrogen (N)	Microkjeldahl method (diacid extraction H_2SO_4: $HClO_4$ in the ratio 5:1)
Phosphorus (P)	Vanadomolybdate yellow colour method (Triple acid extraction HNO_3: H_2SO_4: $HClO_4$ in the ratio of 9:2:1)
Potassium (K)	Flame photometer method (Triple acid extract)
Chlorophyll	Calorimetric method
Zn & Fe	Triple acid extract by atomic absorption spectrophotometer
Boron (B)	Curcumin method

3. Results

Laboratory evaluation

1. Germination, growth, and chlorophyll concentration in black gramme seedlings as a function of pre-soak time

Compared to the control group, black gramme ADT 3 seed quality characteristics were significantly impacted by the chemical seed soaking treatment. The results showed that alone applying either macronutrients or micronutrients had no noticeable effect on seed quality traits, but applying both had a substantial impact. ZnSO4 100 ppm and MnSO4 100 ppm were shown to be the most effective micronutrient additions to 1% KCl, outperforming Amm.molybdate 25 ppm, Cobalt nitrate 25 ppm, and FeSO4 100 ppm. Application of T13 - 1% KCl + ZnSO4 100 ppm + MnSO4 100 ppm to soaked seeds resulted in the best

germination rate (98%), root length (18.6 cm), shoot length (19.7 cm), dry matter production (0.32), and vigour index (3753.4).

Table 3: Laboratory investigation on the effect of seed hardening on several seed quality indices in black gramme cv. ADT 3

Treatment	Germination percentage	Root length (cm)	Shoot length (cm)	Dry matter production (seedling-10)	Vigour index
T1-Control	82	16.05	14.98	0.19	2544.46
T2-1% KCl	90	16.98	16.78	0.26	3038.4
T3-ZnSO4 100 ppm	88	16.81	16.42	0.25	2924.24
T4- FeSO4 100 ppm	85	16.63	16.00	0.25	2773.55
T5- MnSO4 100 ppm	91	17.20	17.16	0.26	3126.76
T6-Amm.molybdate 25 ppm	84	16.29	15.33	0.22	2656.08
T7-Cobalt nitrate 25ppm	85	16.46	15.66	0.24	2730.20
T8-1%KCl + ZnSO4 100 ppm	94	18.10	18.96	0.30	3483.64
T9-1% KC l+ FeSO4 100 ppm	94	18.04	18.59	0.29	3443.22
T10-1% KC l+ Amm.molybdate 25 ppm	92	17.41	17.55	0.27	3216.32
T11-1% KCl + Cobalt nitrate 25ppm	93	17.61	17.89	0.28	3301.5
T12-1% KCl + ZnSO4 100 ppm + FeSO4 100 ppm	96	18.12	19.10	0.3	3573.12
T13-1%KCl+ ZnSO4 100 ppm + MnSO4 100 ppm	98	18.60	19.70	0.32	3753.40
T14-1% KCl + Amm.molybdate 25 ppm + Cobalt nitrate 25ppm	93	17.83	18.24	0.29	3354.51
SEd	1.77	0.08	0.16	0.004	20.45
CD (p=0.05)	3.54	0.16	0.32	0.008	40.88

2. Black gramme seed germination, plant height, and chlorophyll content after pelletization

Table shows the effect of several chemical seed pelleting treatments on different seed quality metrics of black gramme ADT 3 compared to the control. Phosphorus, potassium, zinc, cobalt, and molybdenum have all been shown to be essential for improving seed quality in a number of different ways.

Table 4: Influence of seed pelleting treatments on seed quality characteristics in black gram cv. ADT 3

Treatment	Germination %	Root length (cm)	Shoot length (cm)	Dry matter production (g seedling-10)	Vigour index
T1 - Control	81	16.1	15.17	0.18	2532.87
T2 - DAP 40 g	84	16.61	17.1	0.21	2831.64
T3 - DAP 40 g + KCl 20 g	86	16.92	17.74	0.21	2980.76
T4 - DAP 40 g + ZnSO4 100 mg	91	17.94	19.23	0.26	3382.47
T5 DAP 40 g + Amm . Molybdate 250 mg	90	17.21	18.24	0.24	3190.5
T6 - DAP 40 g + Cobalt nitrate 250 mg	87	17.11	18.1	0.23	3062.4
T7 - DAP 40 g +ZnSO4 100 mg + Amm.Molybdate 250 mg	93	18.82	20.11	0.28	3620.49
T8 - DAP 40 g + ZnSO4 100 mg + Amm . Molybdate 250 mg +Cobalt nitrate 250 mg	95	19.21	20.62	0.30	3783.85
T9 - DAP 40 g + KCl 20 g + ZnSO4 100 mg	93	18.31	19.75	0.26	3573.06
T10 - DAP 40 g + KCl 20 g + ZnSO4 100 mg + Amm . Molybdate 250 mg	96	19.82	20.91	0.32	3910.08
T11 - DAP 40 g + KCl 20 g+ ZnSO4 100 mg + Amm . Molybdate 250 mg + Cobalt nitrate250 mg	98	20.15	22.3	0.35	4160.1
T12 - KCl 20 g	84	16.23	16.72	0.2	2767.8
SEd	2.63	0.07	0.13	0.004	9.1
CD (p=0.05)	5.24	0.13	0.26	0.007	18.2

as compared to the intake of just one or two of these macro- and micronutrients alone or in combination. The greatest increases in germination percentage (98), root length (20.15 cm), shoot length (22.3 cm), DMP (0.35 g seedling-10), and vogour index (4160.1) were seen with

treatment T11 - DAP 40 g + KCl 20 g + ZnSO4 100 mg + Amm. molybdate 250 mg + Cobalt nitrate 250 mg. In terms of germination rate, it was on par with T10, T9, T8, and T7, but better than the other treatments. The importance of including KCl into the seed pelleting process becomes apparent when compared to other measures of seed quality.

2. Response of black gramme in a field experiment to foliar spray with various growth regulators and boosters

- **Growth attributes**

1. Plant height

Table displays the measured plant height at 30, 45, and harvest days after sowing. Foliar applications of nutrients, growth boosters, and growth retardant treatments had a substantial impact on values across the board. In all cases, plant height correlated positively with stage of development.The height of the plants on 30 DAS varied from 47.70 cm to 57.23 cm.

Table 5: Height (in centimetres) of black gramme plants after foliar application of fertilisers and growth regulators at three distinct phases of development

Treatment	Plant height (cm)		
	30 DAS	45 DAS	At harvest
T1-BTEX III-1 + MC120 ppm	47.70	53.93	48.20
T2 -BTEX III-1 + Triacontanol 0.2 %	51.90	55.92	50.20
T3-BTEX III-1 + CCC 250 ppm	51.30	55.40	49.70
T4-BTEX III-2 + MC120 ppm	52.09	56.24	50.41
T5-BTEX III-2 + Triacontanol 0.2 %	53.07	56.93	52.23
T6-BTEX III-2 + CCC 250 ppm	55.18	58.29	53.40
T7-BTEX III-3 + MC120 ppm	55.80	58.02	53.01
T8-BTEX III-3 + Triacontanol 0.2 %	57.23	59.80	55.46
T9-BTEX III-3 + CCC 250 ppm	56.28	59.05	54.61
SEd	0.44	0.21	0.35
CD (p=0.05)	0.93	0.64	0.74

T5 was the tallest at 53.07 cm, followed by T4 at 52.09 cm, T2 at 51.90 cm, T3 at 51.30 cm, and T1 at the shortest at 47.70 cm. Comparable results were seen for Treatments 6 and 7,

Treatments 4 and 2, and Treatments 2 and 3.The height of the plants varied between 53.93 cm and 59.80 cm throughout 45 DAS. T8 - BTEX III - 3 + Triacontanol 0.2% again produced the tallest plants at this stage (59.80 cm), followed by T9 (59.05 cm), T6 (58.29 cm), T7 (58.02 cm), T5 (56.93 cm), T4 (56.24 cm), T2 (55.9 cm 2), T3 (55.40 cm), and T1 (53.93 cm). Treatments T6 and T7 were comparable, as were T4 and T2, and T2 and T3, whereas all other treatments differed significantly from one another.

Plant height varied between 48.20 cm and 55.46 cm during harvest. The T8 - BTEX III - 3 + Triacontanol 0.2% treatment produced the tallest plants at this stage (55.46 cm), followed by the T9 (54.61 cm), T6 (53.40 cm), T7 (53.01 cm), T5 (52.23 cm), T4 (50.41 cm), T2 (50.20 cm), T3 (49.70 cm), and the T1 treatment (48.20 cm). There was little to no difference between T6 and T7, T4 and T2, or T2 and T3, but all the other treatments were dissimilar.

2. Leaf Area Index

Table displays the leaf area index measurements taken at 30 and 45 DAS, representing two distinct phases of development. Foliar applications of nutrients, growth boosters, and growth retardant treatments had a substantial impact on values across the board.

The LAI on 30 DAS fluctuated between 2.07 and 2.27.For example, T8 - BTEX III - 3 + Triacontanol 0.2% had a leaf area index of 2.27, whereas T9 had 2.24, T6 had 2.21, T7 had 2.20, T5 had 2.14, T4 had 2.11, T2 had 2.10, T3 had 2.10cm, and T1 had 2.07. Comparable results were seen for Treatments 6 and 7, Treatments 4 and 2, and Treatments 2 and 3.

The leaf area index varied from 2.38 to 2.69 over 45 DAS. The greatest leaf area index was 2.69 at this time for treatment T8 - BTEX III - 3 + Triacontanol 0.2%. The next lowest value was reported by treatment T1 (2.38), then T9 (2.65) followed by T6 (2.61) T7 (2.68) T5 (2.51) T4 (2.57) T2 (2.45) T3 (2.42) and T4 (2.51). Similar results were shown between T6 and T7, T4 and T2, and T2 and T3, whereas substantial differences were seen between all other treatments.

Table 6: Leaf area index and chlorophyll concentration (mg 100 g-1 tissue) of black gramme throughout development stages as affected by foliar application of nutrients and growth retardants

Treatment	Leaf area index		Chlorophyll content (mg 100 g-1)	
	30 DAS	45 DAS	30 DAS	45 DAS
T1-BTEX III-1 + MC120 ppm	2.07	2.38	27.43	29.80
T2 -BTEX III-1 + Triacontanol 0.2 %	2.10	2.45	28.44	30.80

T3-BTEX III-1 + CCC 250 ppm	2.10	2.42	27.98	30.39
T4-BTEX III-2 + MC120 ppm	2.11	2.47	28.95	31.26
T5-BTEX III-2 + Triacontanol 0.2 %	2.14	2.51	29.65	31.80
T6-BTEX III-2 + CCC 250 ppm	2.21	2.60	30.78	32.90
T7-BTEX III-3 + MC120 ppm	2.20	2.58	30.24	32.39
T8-BTEX III-3 + Triacontanol 0.2 %	2.27	2.69	31.83	33.78
T9-BTEX III-3 + CCC 250 ppm	2.24	2.65	31.31	33.40
SEd	0.006	0.015	0.211	0.16
CD (p=0.05)	0.01	0.03	0.44	0.33

3. Chlorophyll content at 30 and 45 DAS

Table displays the findings of chlorophyll concentration. Nutrient, growth promoter, and growth inhibitor foliar applications all had significant effects on chlorophyll concentration (mg 100 g-1 tissue).

The chlorophyll concentration of tissues at 30 DAS varied from 27.43 mg 100 g-1 to 31.83 mg 100 g-1.The highest chlorophyll content per unit of tissue was found in T8 - BTEX III - 3 + Triacontanol 0.2%, followed by T9 (31.31 mg 100 g-1), T6 (30.78 mg 100 g-1), T7 (30.24 mg 100 g-1), T5 (29.65 mg 100 g-1), T4 (28.95 mg 100 g-1), T2 (28.44 mg 100 g-1), T3 (27. Similar results were shown between T6 and T7, T4 and T2, and T2 and T3, whereas substantial differences were seen between all other treatments.

The chlorophyll concentration of 45 DAS tissues varied from 29.80 mg 100 g-1 to 33.78 mg 100 g-1. During this stage also treatment T8 - BTEX III - 3 + Triacontanol 0.2% recorded the highest chlorophyll content of 33.78 mg 100 g-1tissue which was followed by T9 (33.40 mg 100 g-1), T6 (32.90 mg 100 g-1), T7 (32.39 mg 100 g-1), T5 (31.80 mg 100 g-1), T4 (31.26 mg 100 g-1), T2 (30.80 mg 100 g-1), T3 (30.39 mg 100 g-1) and T1 recorded the lowest chlorophyll content of 29.80 mg 100 g-1 tissue. Treatments T6 and T7, T4 and T2, and T2 and T3 were comparable, but all other treatments had statistically significant differences from one another.

4. Dry matter production

Table displays the results of measurements taken at 30 and 45 DAS to determine dry matter production. Foliar applications of nutrients, growth boosters, and growth retardant treatments had a substantial impact on values at 30 and 45 DAS.Production of dry matter on 30 DAS varied from 752 to 937 kilogrammes per hectare.Dry matter production ranged from 758 kg ha-1 in T1 to 937 kg ha-1 in T8 - BTEX III - 3 + Triacontanol 0.2%, with T9 producing 906

kg ha-1, T6 producing 877 kg ha-1, T7 producing 865 kg ha-1, T5 producing 838 kg ha-1, T4 producing 809 kg ha-1, T2 producing 796 kg ha-1, and T3 producing 783 kg ha-1. Similar results were shown between T6 and T7, T4 and T2, and T2 and T3, whereas substantial differences were seen between all other treatments.

Table 7: Dry matter production (kg ha-1) of black gramme at various development stages as influenced by foliar application of nutrients as well as growth retardants

Treatment	Dry matter production (kg ha-1)	
	30 DAS	45 DAS
T1-BTEX III-1 + MC120 ppm	758	1428
T2 -BTEX III-1 + Triacontanol 0.2 %	796	1482
T3-BTEX III-1 + CCC 250 ppm	783	1463
T4-BTEX III-2 + MC120 ppm	809	1506
T5-BTEX III-2 + Triacontanol 0.2 %	838	1551
T6-BTEX III-2 + CCC 250 ppm	877	1618
T7-BTEX III-3 + MC120 ppm	865	1593
T8-BTEX III-3 + Triacontanol 0.2 %	937	1709
T9-BTEX III-3 + CCC 250 ppm	906	1663
SEd	8.02	14.62
CD (p=0.05)	17.00	30.00

The dry matter yield on 45 DAS varied between 1428 and 1709 kg ha-1. The treatments with the highest dry matter production were T8 - BTEX III - 3 + Triacontanol 0.2% (1709 kg ha-1), followed by T9 (1663 kg ha-1), T6 (1615 kg ha-1), T7 (1593 kg ha-1), T5 (1551 kg ha-1), T4 (1506 kg ha-1), T2 (1482 kg ha-1), and T3 (1463 kg ha-1). Similar results were shown between T6 and T7, T4 and T2, and T2 and T3, whereas substantial differences were seen between all other treatments.

- **Nutrient uptake**

Nitrogen uptake

Table displays the results of research on the absorption of nitrogen by grain. Treatments with foliar nutrients, growth regulators, and growth promoters had a considerable impact on grain N

absorption. Grains absorbed between 30.38 to 37.90 kilogrammes of nitrogen per hectare. All treatments except T6 and T7, T4 and T2, and T2 and T3 were statistically significant with one another.

Phosphorus uptake

Table displays the results of research on grain P uptake. Foliar administration of nutrients, growth boosters, and growth retardant treatments had a considerable impact on grain P absorption. All treatments except T6 and T7, T4 and T2, and T2 and T3 were statistically significant with one another.

Potassium uptake

Table summarises the research on how much potassium grains absorb. Foliar administration of nutrients, growth boosters, and growth retardant treatments greatly impacted K absorption in grain. Grain K intake varied from 13.10 to 16.80 kg HA-1. All other treatments were statistically significant with T2, T2, and T3, and with each other.

Table8: Grain NPK absorption as a function of foliar application of nutrients & growth regulators (kg ha-1)

Treatment	N uptake (kg ha-1)	P uptake (kg ha-1)	K uptake (kg ha-1)
T1-BTEX III-1 + MC120 ppm	30.38	5.63	13.10
T2 -BTEX III-1 + Triacontanol 0.2 %	33.62	6.08	13.95
T3-BTEX III-1 + CCC 250 ppm	32.80	5.98	13.75
T4-BTEX III-2 + MC120 ppm	33.87	6.19	14.45
T5-BTEX III-2 + Triacontanol 0.2 %	35.07	6.40	15.14
T6-BTEX III-2 + CCC 250 ppm	36.06	6.71	15.53
T7-BTEX III-3 + MC120 ppm	35.84	6.62	15.34
T8-BTEX III-3 + Triacontanol 0.2 %	37.90	7.12	16.80
T9-BTEX III-3 + CCC 250 ppm	37.01	6.93	16.18
SEd	0.37	0.08	0.28
CD (p=0.05)	0.80	0.17	0.5

- **Soil fertility after harvest**

Nitrogen

Table displays information on KMnO4 - N levels in soil after harvest. Foliar application of nutrients, growth enhancers, and growth retardant treatments considerably impacted the KMn O4 - N in post-harvest soils. T1 had the highest KMnO4 - N at 160 kg ha-1, followed by T3 with 158 kg ha-1, T2 with 157 kg ha-1, T4 with 157 kg ha-1, T5 with 155 kg ha-1, T7 with 154 kg ha-1, T6 with 153 kg ha-1, T9 with 151 kg ha-1, and T8 with BTEX III - 3 + Triacontanol 0.2% with 149 kg ha-1. Similar results were seen when comparing treatments T6 and T7, T4 and T2, and T2 and T3.

Phosphorus

Table displays the Olsen - P values in the soil after harvest. Foliar application of nutrients, growth boosters, and growth retardant treatments substantially affected Olsen - P in post-harvest soils. The Olsen-P value was 13.10 kg ha-1 for Treatment 1, 12.24 kg ha-1 for Treatment 2, 12.09 kg ha-1 for Treatment 4, 11.82 kg ha-1 for Treatment 5, 11.53 kg ha-1 for Treatment 7, 11.43 kg ha-1 for Treatment 6, 11.24 kg ha-1 for Treatment 9, and 11.78 kg ha-1 for Treatment 8 - BTEX III - 3 + Triacontanol 0.2%. There was no statistically significant difference between T6 and T7, T4 and T2, or T2 and T3.

Potassium

Table displays information on post-harvest soil NH4OAc-K levels. Foliar application of nutrients, growth enhancers, and growth retardant treatments substantially impacted NH4OAc - K in post-harvest soils. T1 recorded 340 kg ha-1 of NH4OAc - K, followed by T2 with 328 kg ha-1, T4 with 324 kg ha-1, T5 with 316 kg ha-1, T7 with 309 kg ha-1, T6 with 315 kg ha-1, T9 with 308 kg ha-1, and T8 with BTEX III - 3 + Triacontanol 0.2% with 302 kg ha-1. Similar results were seen when comparing treatments T6 and T7, T4 and T2, and T2 and T3.

Table 9: Post-harvest N, P, and K levels in the soil as a result of foliar applications of nutrients and growth regulators (kg ha-1)

Treatment	KMnO4-N (kg ha-1)	Olsen-P (kg ha-1)	NH4OAc - K (kg ha-1)
T1-BTEX III-1 + MC120 ppm	160	13.10	340
T2 -BTEX III-1 + Triacontanol 0.2 %	157	12.09	328
T3-BTEX III-1 + CCC 250 ppm	158	12.24	332
T4-BTEX III-2 + MC120 ppm	157	11.82	324

T5-BTEX III-2 + Triacontanol 0.2 %	155	11.53	316
T6-BTEX III-2 + CCC 250 ppm	153	11.24	315
T7-BTEX III-3 + MC120 ppm	154	11.43	309
T8-BTEX III-3 + Triacontanol 0.2 %	149	11.78	302
T9-BTEX III-3 + CCC 250 ppm	151	11.52	308
SEd	0.56	0.10	23.58
CD (p=0.05)	1.2	0.21	49.99

4. Conclusion

Due to insufficient fertiliser management, rice fallow black gramme provides a meagre harvest. The researchers used a comprehensive approach by including the use of growth regulators and growth retardants as well as macro- and micronutrients in their analysis. According to the results of the current study's trials, black gramme shows a notable response to nutrient delivery by foliar spray. Therefore, it can be concluded that the best strategy for maximising black gramme yield in Typic Haplusterts soil is to apply a seed soaking treatment consisting of 1% KCl + ZnSO4 100 ppm + MnSO4 100 ppm, followed by foliar sprays of DAP 2% + 0.5% ZnSO4 + 0.5% FeSO4 + 0.1% Boric acid + 0.05% Sodium molybdate + 0.05% CoCl2 and NA.

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