



Weed and nitrogen management in rainfed baby corn (*Zea mays* L.) and its impact on yield and economics of succeeding black gram (*Vigna mungo* (L.) Hepper)

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Abstract

The carryover effects of weed and nitrogen management in baby corn can significantly influence the growth, nodulation and yield of a succeeding black gram crop through residual soil fertility and weed-free seedbeds. Field experiments were conducted at Bhubaneswar, Odisha, India to assess the effect of weed and nitrogen management in baby corn on performance of succeeding black gram. Four weed management practices allocated to the main plots and 5 nitrogen management practices to supply 100 % soil-test based nitrogen (STBN) allocated to the subplots were evaluated in split plot design with 3 replications. Weed management practices comprised application of pre-emergence herbicide alone, combination (tank-mix) of two post-emergence herbicides, integrated weed management and cultural method alone. Nitrogen management treatments were based on varying proportions of chemical fertiliser (urea), farm yard manure (FYM) and vermicompost (VC). Integrated weed management comprising atrazine + manual weeding in baby corn reduced weed density by 41, 43 and 55 % and biomass by 34, 31 and 47 % respectively, compared to atrazine 1.0 kg ha⁻¹ alone (pre-emergence), tembotrione + 2,4-D (post-emergence) and cultural method (hoeing and weeding) alone and improved growth, yield and economics of succeeding black gram. Integrated nitrogen management practices recorded higher values of these traits than chemical nitrogen alone. Integrated weed management through combination of atrazine at 1.0 kg ha⁻¹ + manual weeding at 21 days after sowing (DAS) and supply of 100 % soil test-based nitrogen through 75 % STBN (urea) + 25 % STBN (VC) reduced weed growth to the minimum and gave the maximum grain yield of 798 kg ha⁻¹, net return of ₹34529 ha⁻¹ and return per rupee invested of 2.58. Combinations of integrated weed management with 50 % STBN (urea) + 25 % STBN (FYM) + 25 % STBN (VC) and 75 % STBN (urea) + 12.5 % STBN (FYM) + 12.5 % STBN (VC) were at par for these indices. Grain yield was positively associated with pods per plant (0.477*) and haulm yield (0.888**) and negatively associated with weed density (-0.539*) and weed biomass (-0.595**). These findings underscore the importance of integrated weed and nitrogen management for better performance of succeeding crop in baby corn-black gram sequence cropping system.

Keywords: atrazine; gross return; net return; tembotrione; 2,4-D; weed

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1. Introduction

Green gram and black gram fit well into baby corn-pulse sequential cropping systems due to their short life span of the component crops. In high rainfall areas, black gram tolerates transient waterlogging better than green gram (1, 2). Baby corn is an important vegetable and fodder crop. Black gram, used for preparing dal, dosa, idli and utthappam, plays a pivotal role in food diversity. During 2024–25, it occupied an area of 31.57 lakh ha giving production of 22.42 lakh tonnes and productivity of 710 kg ha⁻¹ (3). The crop is grown on the bunds of rice fields during the kharif season to fulfill domestic requirements in the rainfed areas of Eastern India. It can be grown after baby corn under broad bed and furrow

method of planting to avoid adverse effects of excess rainfall. The legume component in baby corn-based intercropping or sequence cropping systems improves land use efficiency, soil fertility, system productivity and energy efficiency through symbiotic nitrogen fixation (4, 5). Both black gram and green gram are ideal legumes for inclusion after maize /baby corn in cropping sequences due to its ability to efficiently utilise residual soil moisture and nutrients and positive effects on soil health and system productivity (6, 7).

Rainfed baby corn in kharif is infested by broad-spectrum weed flora due to congenial moisture and thermal regimes. Effective weed management in baby corn/corn reduces weed competition, exerts positive

residual effects on succeeding crops in cropping systems and enhances productivity (7, 8). Application of atrazine 1.0 kg ha^{-1} + manual weeding at 21 days after sowing (DAS) tackles weeds in kharif baby corn effectively (9, 10). Weed management reduces nutrient depletion by weeds, thereby conserving more soil nutrients for subsequent crops in the system. In most cases, proper herbicide application even improves growth and vigour of succeeding crops due to better weed control in the previous crop (11). Further, residual effects of herbicides applied to baby corn should not exert phytotoxic effects on the succeeding crops. Above detectable level of residue in soil was noticed with sequential application of atrazine as pre-emergence spray followed by post-emergence spray of tembotrione or sole application of tembotrione at 20 DAS in kharif maize, but the succeeding sunflower crop was free from residual carry over effect (12). Effective weed management in maize reduced weed seed bank, thereby lowering potential weed infestation in succeeding sunflower (13). Weed control practices and herbicides in maize showed positive residual effects on succeeding wheat crop (14). Atrazine 1.0 kg ha^{-1} (pre-emergence) in combination with tembotrione 120 g ha^{-1} (post-emergence) did not exert any adverse effects on soil microbial activity and growth of succeeding green gram (15).

Application of recommended dose of nitrogen (RDN) through inorganic and organic sources exert direct and residual effects on the crops in the cropping system. Integrated nitrogen management (INM) in baby corn significantly improved soil health, microbial diversity and activity and yield of the succeeding rice (16) and hyacinth bean (17). Yields of baby corn in the rabi season were higher following the application of the recommended dose of fertiliser (RDF) + FYM at 10 t ha^{-1} , 75 % RDN (chemical) + 25 % RDN (VC) and 75 % RDN (chemical) + 25 % RDN (bio compost). In summer, the residual effect of 100 % RDF + FYM at 10 t ha^{-1} applied to rabi maize showed higher grain and stover yields of green gram followed by 75 % RDN through chemical fertiliser + 25 % RDN through vermicompost (6). Integrated supply comprising 75 % RDF, FYM at 5 t ha^{-1} and mixed bio fertilisers and 75 % RDF, VC at 2.5 t ha^{-1} and mixed bio fertilisers in baby corn gave higher grain and haulm yield of green gram than chemical fertiliser alone and 75 RDF + sun hemp green manuring + mixed bio-fertiliser at Bhubaneswar, India (18). Integrated supply system comprising 75 % RDN (urea) and 50 % RDN (FYM) and 25 % RDN (VC) in kharif maize had positive impacts on growth, yield attributes and yield of succeeding green gram at Byrasandra village, Karnataka, India (19). Continuous application of chemical fertilisers in baby corn degrades soil health. Nutrient availability to baby corn is better under integrated supply systems, whereas nutrient retention for succeeding crops is better with application of organic sources (20).

Weed and nitrogen management in maize/baby corn act synergistically to improve performance of the succeeding crop. Residual effects of weed and nitrogen management in maize influenced growth parameters,

yield (pod and haulm) and economics of succeeding groundnut significantly, but the germination percentage of the succeeding crop and phyto-toxicity remained unaffected. Weed management in maize included herbicidal methods viz., atrazine 1.0 kg ha^{-1} (pre-emergence) followed by topamezone 30 g ha^{-1} (post-emergence) and atrazine 1.0 kg ha^{-1} (pre-emergence) followed by tembotrione 120 g ha^{-1} (post-emergence) (21).

Studies on weed and nitrogen management in baby corn-based sequential cropping systems are limited. Therefore, this study was conducted to evaluate the residual effects of different weed and nitrogen management practices in baby corn on the growth, yield, weed dynamics and economic performance of succeeding black gram under rainfed conditions.

2. Materials and Methods

Experimental site

A field experiment was conducted to study the direct and residual effects of integrated weed and nitrogen management in a baby corn-black gram cropping system at the Agricultural Research Station, Faculty of Agricultural Sciences (IAS), Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, Odisha, India during the kharif and pre-rabi seasons of 2022 and 2023. The experimental site is geographically located at $20^{\circ}25' \text{ N}$ latitude and $85^{\circ}67' \text{ E}$ longitude, with an altitude of 51 m above mean sea level. The region falls under the East and Southeastern Coastal Plain Agro-climatic Zone of Odisha. The climate of Bhubaneswar is characterised by hot, moist and sub-humid climate with hot summer and mild winter. The rainfall is monsoonal and unimodal. The southwest monsoon in Odisha usually sets in around mid-June and recedes by mid-October. Average annual rainfall is 1658 mm. Nearly, 76 % of the annual rainfall is received between June to September. The mean maximum and minimum temperature are 33 and 22.4°C respectively. The month of May is the hottest with the mean maximum and minimum temperatures of 37.7 and 26.7°C (mean 32.2°C) and the month of January is the coldest with the mean maximum and minimum temperature of 29.2 and 15.5°C (mean 22.4°C) respectively.

Soil characteristics of experimental site

The experimental field was a well-drained upland with uniform topography. The soil is classified as sandy clay loam in texture. It was acidic in reaction (pH 5.23) with low electrical conductivity (0.31 dS m^{-1} at 25°C). The soil was low in chemical properties viz., organic carbon (0.28 %), available nitrogen ($187.57 \text{ kg ha}^{-1}$), available phosphorus (4.80 kg ha^{-1}) and potassium (79.80 kg ha^{-1}) and these were determined by using Walkley-Black chromic acid wet oxidation method (22), alkaline permanganate method (23), Bray's method (22) and flame photometer method (24), respectively.



Experimental design and treatment details

The following 4 main plot treatments and 5 subplot treatments were evaluated in split-plot design with 3 replications.

Main plot treatments (Weed management)

W₁: Atrazine at 1.0 kg ha⁻¹ (pre-emergence)

W₂: Tembotrione at 90 g ha⁻¹ + 2,4-D at 400 g ha⁻¹ (post-emergence)

W₃: Atrazine at 1.0 kg ha⁻¹ + Manual weeding at 21 DAS

W₄: Hoeing and weeding at 21 DAS

Sub plot treatments (Nitrogen management)

N₁: 100 % Soil test-based nitrogen (STBN) through urea

N₂: 75 % STBN (urea) + 25 % STBN (FYM)

N₃: 75 % STBN (urea) + 25 % STBN (vermicompost)

N₄: 75 % STBN (urea) + 12.5 % STBN (FYM) + 12.5 % STBN (vermicompost)

N₅: 50 % STBN (urea) + 25 % STBN (FYM) + 25 % STBN (vermicompost)

The soil was low in available nitrogen. Hence, the soil test-based nitrogen recommendation was 150 kg ha⁻¹ (25 % higher than the recommended dose of 120 kg N ha⁻¹). Accordingly, 75 kg P₂O₅ and 75 kg K₂O was applied to baby corn.

Crop management

Baby corn

The baby corn variety 'Syngenta G-5414' was sown on 7 July 2022 and 13 July 2023 and harvested during 24–29 August 2022 and 2–6 September 2023. Atrazine 1.0 kg ha⁻¹ was applied as pre-emergence herbicide

using a knapsack sprayer fitted with a flat fan nozzle as per treatment. Post-emergence herbicides were applied using a cone nozzle. All recommended agronomic practices and plant protection measures were followed to raise a healthy crop.

Succeeding black gram

After the harvest of baby corn, black gram was grown with recommended package of practices as a residual crop to evaluate the carryover effects of the treatments. The gross and net plot size were 4.8 × 4.0 and 3.6 × 3.4 m respectively. The variety 'Shashi (OBG-33)' released from OUAT, Bhubaneswar in 2020 was used for the study. The field was prepared by cleaning bunds and furrows prior to sowing. Sowing was carried out on 24 September 2022 (39th SMW) and 27 September 2023 (39th SMW) using a seed rate of 25 kg ha⁻¹. Both baby corn and black gram were grown on broad beds under broad bed and furrow (BBF) method of planting (Fig. 1). In each bed, 4 rows of black gram with row-to-row distance of 25 cm and plant to plant distance of 10 cm were accommodated (Fig. 2). The crop was raised with residual soil fertility without applying any fertiliser. Thinning was done 2 weeks after sowing to maintain optimum plant population. Quizalofop-ethyl at 0.05 kg ha⁻¹ was applied uniformly at 21 DAS after recording weed density and biomass to control the dominant grassy weed species *Digitaria sanguinalis* L. Initially the crop was grown as a rainfed crop, but two irrigations were provided at critical stages, namely flowering and pod development stage for proper pod setting and grain filling. The crop was harvested on 29 November 2022 (48th SMW) and 02 December 2023 (48th SMW), when the pods turned brown. Plot-wise grain yield was recorded after threshing, cleaning and sun drying and expressed as kg ha⁻¹ at an 8 % moisture content.

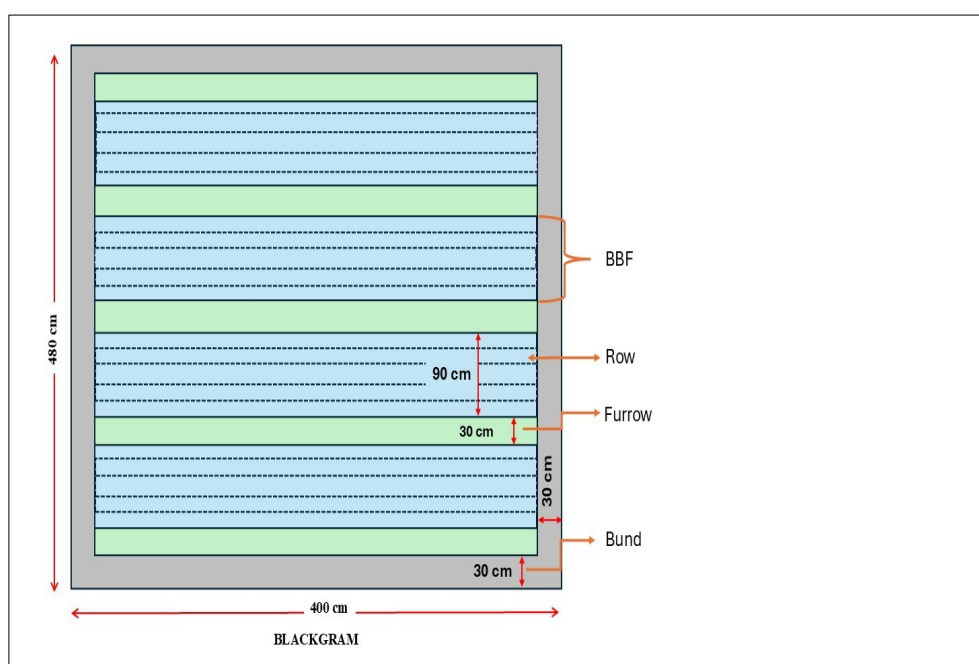


Fig. 1. Layout of broad beds and furrows (BBF) in the field for sowing black gram. Each broad bed accommodated 4 rows of black gram.

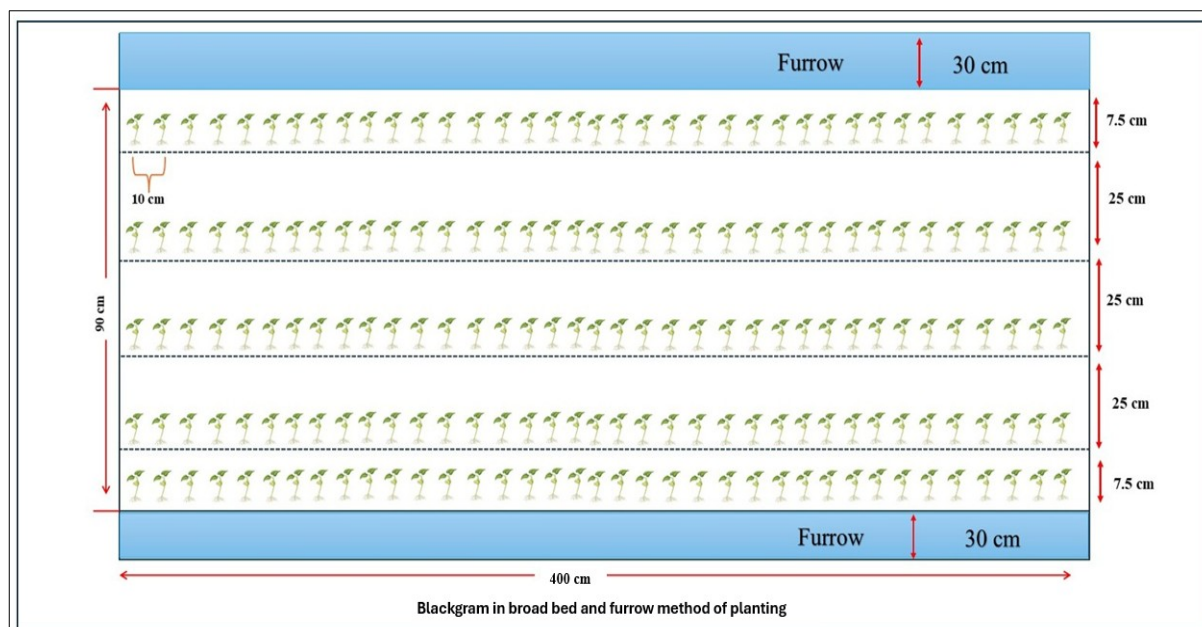


Fig. 2. Schematic presentation of planting pattern for black gram.

Each broad bed has width of 90 cm. Furrows of width 30 cm were provided between two beds. In each bed, 4 rows of black gram were sown.

Pre-harvest observations

Plant height and branches per plant were recorded from 10 randomly selected and tagged plants. Observation on leaf area, nodule number and dry weight and dry matter accumulation were recorded by collecting sample plants from destructive sampling zone. The height of 10 randomly selected plants from each subplot was recorded from ground level to the tip of the main shoot with the help of a meter scale. The average value of 10 plants was taken as the mean plant height. The number of branches in the selected plants was recorded and averaged out to get the number of branches per plant. The leaves of sample plants collected from the destructive sampling zone were detached to record leaf area of each plant by a leaf area meter and the average value was calculated. The leaf area index (LAI) was calculated by using the following formula (25).

$$\text{LAI} = \frac{\text{Leaf (cm}^2\text{)}}{\text{Ground (cm}^2\text{)}} = \frac{\text{Total leaf area of plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}} \quad \text{Eq. 1}$$

Dry matter production

The above ground portions of the sample plants from destructive sampling zone of each plot were collected for dry matter study. The collected samples were sun dried for a period of 2 days and then oven dried at 70 °C till the constant weight was obtained.

Number and dry weight of nodules per plant

The number and dry weight of effective nodules from the uprooted sample plants were recorded and average value was worked out to get the nodule number and dry weight per plant.

Crop growth rate (CGR)

This is an index of the amount of growing material per unit area per unit time. The CGR was expressed in $\text{g m}^{-2} \text{ day}^{-1}$. If W_1 and W_2 are the total dry weights (g m^{-2}) at time t_1 and t_2 respectively, the mean value of CGR for the time interval $t_2 - t_1$ is computed by the following formula (26).

$$\text{CGR (g m}^{-2} \text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1} \quad \text{Eq. 2}$$

Post harvest observation

Pods per plant

Total pods from the sampled plants were collected, counted and their average was taken as the number of pods per plant for each treatment.

Seeds per pod

Ten pods were taken from the sample plants from each treatment and threshed. The total seeds were counted and averaged out to obtain the number of seeds per pod.

Test weight

After proper cleaning 1000 seeds from each treatment were counted and weighed to get test weight.

Yield

The plants from the net plot area were harvested treatment-wise and dried under sun before threshing. After cleaning, grain was again dried to get moisture content 8 % before recording weight and yield was expressed as kg ha^{-1} . After threshing, haulm and chaff of different plots were sun dried, weighed separately and expressed as kg ha^{-1} .

Economics

The cost of cultivation was computed by considering the cost of various inputs at the prevailing market rates. Net return for each treatment was calculated by deducting the total cost of cultivation from the gross value of the produce i.e. grain and haulm. The minimum support price (MSP) for grain and market price of haulm were considered for calculating gross return from the crop under various treatments. The return per rupee invested was worked out by dividing the gross return by the total cost of cultivation.

Statistical analysis

The experimental data were analysed statistically using analysis of variance (ANOVA) appropriate for a split-plot design in IBM SPSS statistics (version 28). Treatment means were compared using critical difference (CD) at 5 % level of significance ($p = 0.05$). The 2 years data were subjected pooled analysis, when error variances of both years were found homogenous as per Bartlett test.

3. Results and Discussion

Weed flora, density and biomass

Black gram was infested by nine different weed species comprising 2 grasses, 2 sedges and 5 broadleaved weeds (Table 1). Atrazine followed by manual weeding significantly reduced weed density and biomass at 21 DAS compared with the other weed management practices (Table 2). Among N management practices,

50 % STBN (Urea) + 50 % STBN (FYM and VC) recorded the maximum weed density (9.4 quadrat⁻¹) and biomass (8.4 g quadrat⁻¹) and proved significantly inferior to other nitrogen management practices. Interaction effect of weed and nitrogen management practices were significant on weed density and biomass. The treatment combination W₃N₃ was the most efficient in weed control with the minimum weed density (3.3 quadrat⁻¹) and biomass (3.1 g quadrat⁻¹).

Plant height and branches per plant

Nitrogen and weed management in baby corn exerted significant influence on plant height and branches per plant of succeeding black gram (Table 3). Residual weed management with atrazine followed by manual weeding produced the tallest plants at 20 DAS (12.4 cm) and 40 DAS (39.2 cm), whereas differences were not significant at later growth stages. In case of branches per plant, application of atrazine 1.0 kg ha⁻¹ + one manual weeding recorded the maximum branches per plant, being at par with atrazine 1.0 kg ha⁻¹ alone at 20 and 40 DAS and PM. Among nitrogen management practices, application of 100 % N through urea recorded the minimum plant height and branches per plant. All other sources of nitrogen recorded significantly higher plant height and branches per plant. Among the sources, application of 75 % STBN (Urea) + 25 % STBN (VC) (N₃) recorded the maximum values of these two growth parameters. The integrated N management practices, i.e. N₄ and N₅ at 20 DAS, N₂, N₄ and N₅ at 40 DAS and N₂ at 60 DAS recorded statistically similar branches per plant.

Table 1. Weed flora of black gram at the experimental site

Broad group	Scientific name	Common name	Family	Ontogeny
Grass	<i>Digitaria sanguinalis</i> L.	Large crab grass	Poaceae	Annual
	<i>Eleusine indica</i> (L.) Gaertn.	Goose grass	Poaceae	Annual
Sedge	<i>Cyperus iria</i> L.	Rice flat sedge	Cyperaceae	Annual
	<i>Cyperus rotundus</i> L.	Purple nut sedge	Cyperaceae	Perennial
Broadleaved weeds	<i>Amaranthus viridis</i> L.	Pigweed	Amaranthaceae	Annual
	<i>Cleome viscosa</i> L.	Wild mustard	Cleomaceae	Annual
	<i>Commelina benghalensis</i> L.	Tropical spiderwort	Commelinaceae	Perennial
	<i>Corchorus aestuans</i> L.	West African mallow	Tiliaceae	Annual
	<i>Phyllanthus niruri</i> L.	Stonebreaker	Phyllanthaceae	Annual

Table 2. Effect of weed and nitrogen management on weed density and biomass of black gram at 21 DAS

Treatment	N ₁	N ₂	N ₃	N ₄	N ₅	Mean
Weed density (Number of weeds per quadrat)						
W ₁	2.71(6.8)*	2.68(6.7)	2.68(6.7)	3.03(8.7)	3.51(11.8)	2.92(8.0)
W ₂	3.02(8.6)	3.06(8.9)	2.63(6.4)	3.14(9.4)	3.02(8.6)	2.97(8.3)
W ₃	2.35(5.0)	2.47(5.6)	1.94(3.3)	2.09(3.9)	2.59(6.2)	2.29(4.7)
W ₄	3.22(9.9)	3.26(10.1)	3.05(8.8)	3.60(12.5)	3.44(11.3)	3.32(10.5)
Mean	2.83(7.5)	2.87(7.7)	2.57(6.1)	2.96(8.3)	3.14(9.4)	2.87(7.7)
	W	N	WN	NW		
SEm±	0.06	0.03	0.09	0.07		
CD ($p = 0.05$)	0.19	0.09	0.12	0.19		



Weed biomass (grams per quadrat)						
W ₁	2.61(6.3)	2.31(4.8)	2.26(4.6)	3.19(9.7)	3.40(11.1)	2.76(7.1)
W ₂	2.76(7.1)	2.65(6.5)	2.65(6.5)	2.60(6.3)	2.87(7.7)	2.70(6.8)
W ₃	2.56(6.1)	2.36(5.1)	1.91(3.1)	2.02(3.6)	2.54(6.0)	2.28(4.7)
W ₄	3.34(10.7)	2.75(7.1)	2.91(8.0)	3.36(10.8)	3.10(9.1)	3.09(9.0)
Mean	2.81(7.4)	2.52(5.9)	2.43(5.4)	2.79(7.3)	2.98(8.4)	2.71(6.8)
	W	N	WN	NW		
SEm±	0.01	0.03	0.06	0.06		
CD ($p = 0.05$)	0.04	0.08	0.15	0.17		

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea), N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); SEm ±: Standard error of mean; CD: Critical difference; DAS: Days after sowing; FYM: Farm yard manure; VC: Vermicompost quadrat of size 25 × 0.25 m was used for collecting weed samples. WN: Weed management at same or different level of N; NW: Nitrogen management at same level of weed management; *Original values in parentheses and $(X + 0.5)^{1/2}$ transformed values before parentheses.

Table 3. Effect of weed and nitrogen management on plant height and branches per plant in black gram (pooled over 2022 and 2023)

Treatment	Plant height (cm)				Branches per plant			
	20 DAS	40 DAS	60 DAS	PM	20 DAS	40 DAS	60 DAS	PM
Weed management								
W ₁	11.4	38.7	49.3	49.9	2.7	5.2	5.2	5.2
W ₂	11.3	38.4	48.8	50.5	2.6	5.0	5.0	5.1
W ₃	12.4	39.2	49.8	48.9	2.8	5.3	5.3	5.3
W ₄	11.2	38.3	48.0	51.2	2.5	4.8	5.2	5.0
SEm±	0.09	0.1	0.48	0.59	0.03	0.03	0.05	0.02
CD ($p = 0.05$)	0.3	0.3	NS	NS	0.1	0.1	0.1	0.1
Nitrogen management								
N ₁	10.3	35.0	44.5	47.4	2.4	4.8	5.0	4.9
N ₂	11.5	37.8	48.9	48.8	2.6	5.1	5.3	5.1
N ₃	12.9	41.6	52.4	53.2	2.8	5.2	5.4	5.4
N ₄	11.9	39.7	50.0	51.2	2.7	5.2	5.1	5.2
N ₅	11.4	38.7	49.3	49.9	2.7	5.2	5.2	5.2
SEm±	0.13	0.41	0.37	0.35	0.02	0.05	0.04	0.02
CD ($p = 0.05$)	0.4	1.2	1.0	1.0	0.1	0.1	0.1	0.1

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); SEm ±: Standard error of mean; CD: Critical difference; PM: Physiological maturity; DAS: Days after sowing; cm: centimeter.

Leaf area index and dry matter production

Leaf area index was not significantly affected by weed management, whereas integrated nitrogen management significantly increased LAI compared with sole urea application (Table 4). Among N management practices, application of N through urea alone recorded minimum LAI. The integrated N management practices recorded significantly higher LAI than 100 % N through urea alone. Application of N₃ recorded the maximum value of LAI, being at par with N₄ at 20 DAS and N₄ and N₅ PM. Application of atrazine 1.0 kg ha⁻¹ + one manual weeding recorded the maximum dry matter production at all stages, being at par with W₁ and W₂ and significantly superior to W₄. Among nitrogen management practices, application of 100 % STBN through urea alone recorded the minimum dry matter accumulation. All integrated

nitrogen management practices recorded significantly higher dry matter than 100 % STBN (urea).

Nodules and nodule dry weight per plant

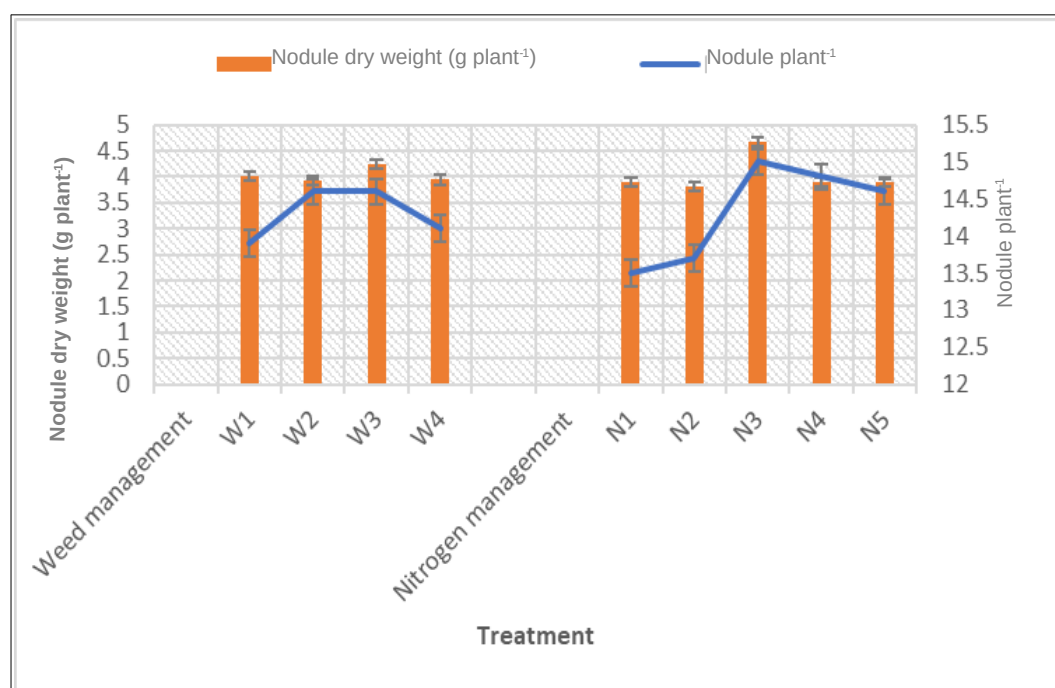
Nodules per plant and nodule dry weight were recorded at 40 DAS. Weed management practices caused significant difference in nodules per plant and caused significant variation in nodules dry weight per plant (Fig. 3). Both atrazine 1.0 kg ha⁻¹ + one manual weeding and tembotrione + 2,4-D (post-emergence) recorded the maximum nodules per plant and proved to be significantly superior to other weed management practices. Atrazine 1.0 kg ha⁻¹ + one manual weeding and 1.0 kg ha⁻¹ alone recorded higher nodule weight per plant than other weed management practices. Integrated nitrogen management (N₃) produced the highest number of nodules (15.0 plant⁻¹) and nodule dry weight (4.67 g plant⁻¹), significantly exceeding the sole urea treatment.



Table 4. Effect of weed and nitrogen management on leaf area index (LAI) and dry matter production (DMP) in black gram (pooled over 2022 and 2023)

Treatment	LAI				DMP (g m ⁻²)			
	20 DAS	40 DAS	60 DAS	PM	20 DAS	40 DAS	60 DAS	PM
Weed management								
W ₁	1.01	3.33	4.41	2.04	21.1	70.4	147.9	197.2
W ₂	0.99	3.33	4.36	2.01	21.0	70.0	146.9	195.6
W ₃	0.99	3.34	4.18	2.04	21.1	70.3	147.7	197.0
W ₄	1.00	3.36	4.31	1.96	20.3	67.6	141.8	189.2
SEm±	0.01	0.04	0.05	0.02	0.1	0.3	0.6	0.9
CD (<i>p</i> = 0.05)	NS	NS	NS	NS	0.3	0.9	2.0	2.7
Nitrogen management								
N ₁	0.88	3.07	4.03	1.87	17.3	57.7	121.1	161.5
N ₂	0.98	3.11	4.20	1.89	20.7	68.8	144.5	192.7
N ₃	1.11	3.79	4.72	2.12	23.9	79.7	167.3	223.4
N ₄	1.10	3.53	4.38	2.11	21.7	72.3	151.7	202.0
N ₅	0.98	3.20	4.25	2.07	20.9	69.4	151.7	194.4
SEm±	0.012	0.047	0.051	0.017	0.1	0.4	0.8	1.0
CD (<i>p</i> = 0.05)	0.04	0.12	0.15	0.05	0.3	0.1	2.1	2.9

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); SEm ±: Standard error of mean; CD: Critical difference; PM: Physiological maturity; DAS: Days after sowing; cm: centimeter.

**Fig. 3.** Effect of weed and nitrogen management in baby corn on nodules per plant and nodule dry weight (g plant⁻¹) at 40 DAS in black gram.

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); Vertical lines above bars indicate standard errors.

Crop growth rate

Crop growth rate increased from 20–40 DAS to 40–60 DAS and declined thereafter across all treatments. Application of atrazine 1.0 kg ha⁻¹ + one manual weeding recorded the maximum value of CGR during 20–40 DAS, 40–60 DAS and 60 DAS - PM (Fig. 4), being a par with and atrazine only and tembotrione + 2,4-D, Hoeing and weeding twice recorded statistically less CGR. All integrated nitrogen management practices recorded significantly higher CGR than 100 % STBN (urea). Application of 75 % STBN (urea) + 25 % STBN (VC) recorded the maximum CGR of 2.79, 4.38 and 3.30 g m⁻² day during 20–40, 40–60 and 60 DAS- PM respectively.

Yield attributes

Among weed management practices application of atrazine 1.0 kg ha⁻¹ + one manual weeding recorded the maximum pods per plant (33.5) and test weight of 1000 grains (41.68 g) (Table 5). Atrazine 1.0 kg ha⁻¹ and tembotrione + 2,4-D recorded the statistically similar pods per plant. In respect of test weight, all other weed management practices recorded significantly less test weight. Hoeing and weeding twice recorded the minimum pods per plant and test weight. Application of 100 % RDN through urea recorded the minimum pod length, per pods plant, seeds per pod and test weight of 1000 seeds. All integrated nitrogen supply systems recorded significantly higher values of these yield attributes. Application of 75 % STBN (urea) + 25 % STBN (VC) recorded the maximum values of all yield attributes, being equal to N₅ for pods per plant and at par with N₄ and N₅ for seeds per pod.

Grain and haulm yield

The grain and haulm yield per plot ranged between 593–977 and 1558–2424 g with haulm to grain spread of 2.29 (W₁N₁)-2.90 (W₄N₄) (Fig. 5). Among weed management practices, combined application of atrazine 1.0 kg ha⁻¹ + one manual weeding gave the maximum grain yield of 711 kg ha⁻¹ and proved significantly superior to all other weed management practices, reflecting yield increases of 13, 9 and 19 % over atrazine 1.0 kg ha⁻¹ alone (W₁), tembotrione + 2,4-D (W₂) and hoeing and weeding twice (W₄) respectively (Table 6). Among N management practices, application of 75 % STBN (urea) + 25 % STBN (VC) gave maximum grain yield of 723 kg ha⁻¹, being at par with 50 % STBN (Urea) + 25 % N (FYM) + 25 % N (VC). Application of 100 % STBN (urea) recorded 26 % less grain yield. The interaction between weed and nitrogen management significantly affected grain yield, with W₃N₃ producing the highest yield (798 kg ha⁻¹), although it remained statistically similar to W₃N₅ (787 kg ha⁻¹) and W₃N₄ (758 kg ha⁻¹). Among weed management practices, atrazine at 1.0 kg ha⁻¹ + manual weeding at 21 DAS (W₃) produced the maximum haulm yield of 1779 kg ha⁻¹ and proved to be significantly superior to other weed management practices, reflecting haulm yield increases of 9, 5 and 12 % over W₁, W₂ and W₄, respectively. Among N management practices, application of 50 % STBN (urea) + 25 % STBN (FYM) + 25 % STBN (VC) (N₅) gave the maximum haulm yield of 1835 kg ha⁻¹, being at par with W₃N₃ (1808 kg ha⁻¹) and significantly superior to all other N management practices. Application of 100% STBN (urea) decreased haulm yield by 23 %. Interaction effect of weed and nitrogen management practices were significant on haulm yield. The treatment combination W₃N₅ gave the maximum haulm yield of 1981 kg ha⁻¹, being at par with combination W₃N₄ (1932 kg ha⁻¹).

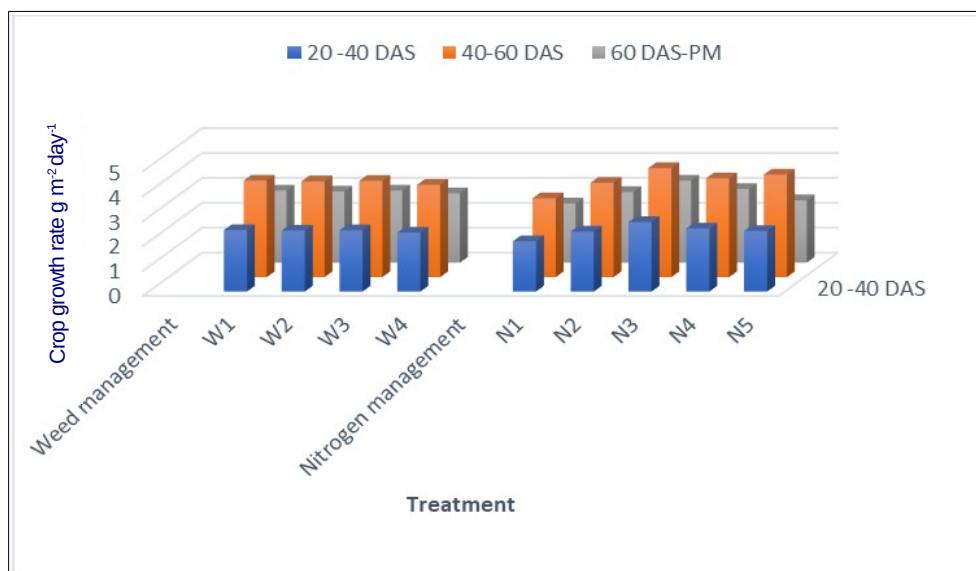


Fig. 4. Effect of weed and nitrogen management in baby corn on Crop growth rate (CGR) of succeeding black gram.

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); DAS: Days after sowing; PM: Physiological maturity.

Table 5. Effect of weed and nitrogen management on yield attributes of black gram (Pooled over 2022 and 2023)

Treatment	Pod length (cm)	Pods per plant	Seeds per pod	Test weight (g)
Weed management				
W ₁	4.7	32.8	4.7	40.03
W ₂	4.8	33.2	4.7	40.81
W ₃	4.7	33.5	4.8	41.68
W ₄	4.6	31.7	4.7	40.72
SEm±	0.04	0.32	0.05	0.16
CD (<i>p</i> = 0.05)	NS	1.0	NS	0.5
Nitrogen management				
N ₁	4.0	22.3	3.7	37.83
N ₂	4.7	31.9	4.4	40.86
N ₃	5.2	37.7	5.4	42.68
N ₄	4.7	34.4	5.2	40.97
N ₅	5.0	37.7	5.2	41.71
SEm±	0.05	0.28	0.08	0.31
CD (<i>p</i> = 0.05)	0.1	0.8	0.22	0.88

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); SEm ±: Standard error of mean; CD: Critical difference; cm: centimeter; g: gram.

Table 6. Effect of weed and nitrogen management in baby corn on yield of black gram (Pooled over 2022 and 2023)

Treatment	N ₁	N ₂	N ₃	N ₄	N ₅	Mean
Grain yield (kg ha⁻¹)						
W ₁	579	698	687	581	590	627
W ₂	528	621	755	607	744	651
W ₃	544	669	798	758	787	711
W ₄	485	594	653	563	689	597
Mean	534	646	723	627	702	646
	W	N	WN	NW		
SEm±	8	9	18	18		
CD (<i>p</i> = 0.05)	25	26	41	52		
Haulm yield (kg ha⁻¹)						
W ₁	1327	1740	1785	1612	1678	1628
W ₂	1470	1544	1853	1682	1892	1688
W ₃	1548	1555	1883	1932	1981	1779
W ₄	1273	1520	1713	1634	1791	1586
Mean	1404	1590	1808	1715	1835	1670
	W	N	WN	NW		
SEm±	22	20	41	39		
CD (<i>p</i> = 0.05)	67	55	84	111		

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); SEm ±: Standard error of mean; CD: Critical difference; FYM: Farm yard manure; VC: Vermicompost; WN: Weed management at same or different level of N; NW: Nitrogen management at same level of weed management.

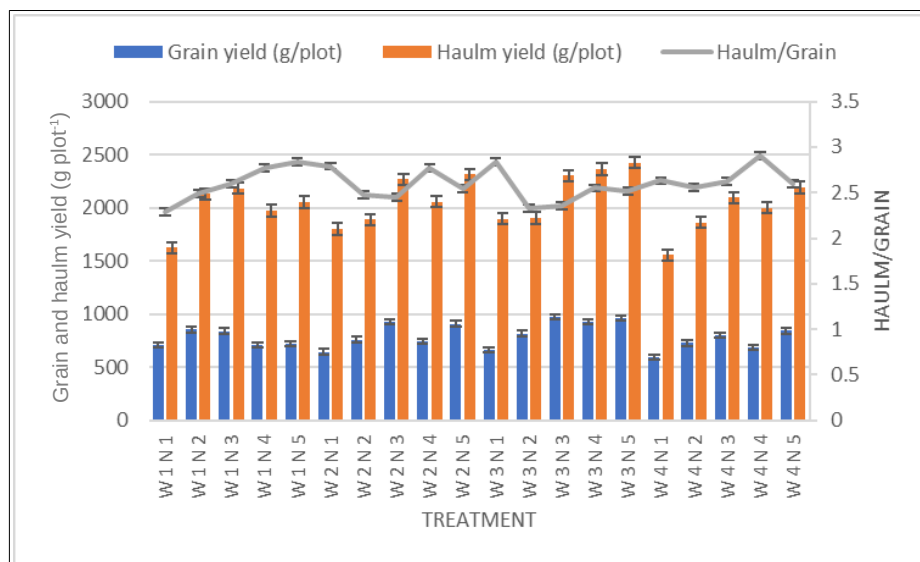


Fig. 5. Effect of weed and nitrogen management in baby corn on grain and haulm yield plot⁻¹ (3.6 × 3.4 m) of black gram.

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally). Vertical lines above line/bars indicate standard errors.

Economics

Integrated weed management comparing atrazine 1.0 kg ha⁻¹ + one manual weeding gave the maximum gross return of ₹50480 ha⁻¹ (Fig. 6). All other weed management practices gave significantly less gross return. Among N management practices, 75 % STBN (urea) + 25 % STBN (VC) accrued maximum gross return of ₹51349 ha⁻¹. Application of 50 % STBN (Urea) + 25 % STBN (FYM) + 25 % STBN (VC) (₹50022 ha⁻¹) gave statistically similar gross return. Interaction effects of weed and nitrogen management exerted significant influence on gross return (Fig. 7). The treatment combination W₃N₃ accrued the maximum gross return of ₹ 56433 ha⁻¹, being at par with W₃N₅ (₹55870 ha⁻¹) and W₃N₄ (₹53858 ha⁻¹). Among weed management practices, atrazine at 1.0 kg ha⁻¹ + manual weeding at 21 DAS (W₃) accrued the maximum net return of ₹28576 ha⁻¹ and proved significantly superior to other the weed management practices (Table 7). The treatments W₁, W₂ and W₄ decreased net return by 20, 13 and 28 % respectively. Among N management practices, 75 % STBN (urea) + 25 % STBN (VC) gave the maximum net return of ₹29445 ha⁻¹, being at par with 50 % STBN (Urea) + 25 % STBN (FYM) + 25 % STBN (VC) (N₅) (₹28118 ha⁻¹). Other N management practices recorded significantly less net return. Interaction effect of weed and nitrogen management practices were significant on net return. The treatment combination W₃N₃ gave the maximum net return of ₹34529 ha⁻¹ being at par with W₃N₅ (₹33966 ha⁻¹). Application of atrazine at 1.0 kg ha⁻¹ + manual weeding at 21 DAS (W₃) recorded the maximum return for rupee invested of 2.30 and proved significantly superior to other weed management practices. Among N management practices, 75 % STBN (urea) + 25 % STBN (VC) (N₃) recorded the maximum return per rupee invested of 2.34. Interaction effect of weed and nitrogen management practices were

significant on return per rupee invested. The treatment combination W₃N₃ gave the maximum return for rupee invested (2.58), being at par with W₃N₅ (2.55).

Correlation studies

Grain yield showed strong positive correlations with haulm yield (0.888**) and pods per plant (0.477*), whereas weed density (-0.539*) and biomass (-0.595**) were negatively correlated with grain yield (Table 8). Haulm yield was positively correlated with branches per plant (0.577**), dry matter production plant at 60 DAS (0.492*), pods per plant (0.535*), seeds per pod (0.497*) and seed yield (0.888**). Plant height exhibited significant positive correlation with dry matter production plant at 60 DAS (0.793**), pods per plant (0.681**) and seeds per pod (0.738**), whereas dry matter production at 60 DAS showed significant positive correlation with haulm yield (0.492*), pods per plant (0.805**) and seeds per pod (0.777**).

Weather-soil-crop relationships

Favourable rainfall distribution during the vegetative stage and supplementary irrigation during reproductive growth created suitable conditions for black gram establishment and yield formation (Fig. 8). The high rainfall at germination and vegetative growth stages did not affect crop growth due to raising of the crop on broad beds. In BBF method, broad beds help in safe disposal of excess water during intense rain and furrows help in infiltration and storage of rainwater in soil profile for crop use at subsequent stages during dry spell (27, 28). The crop was irrigated twice (5 cm depth each time) at flowering and pod development stage. The crop was free from serious disease and insect pest attack. Both the maximum and the minimum temperatures declined progressively from 39th to the 48th SMW (Fig. 9). The crop was harvested before the onset of low temperature period during both the years.

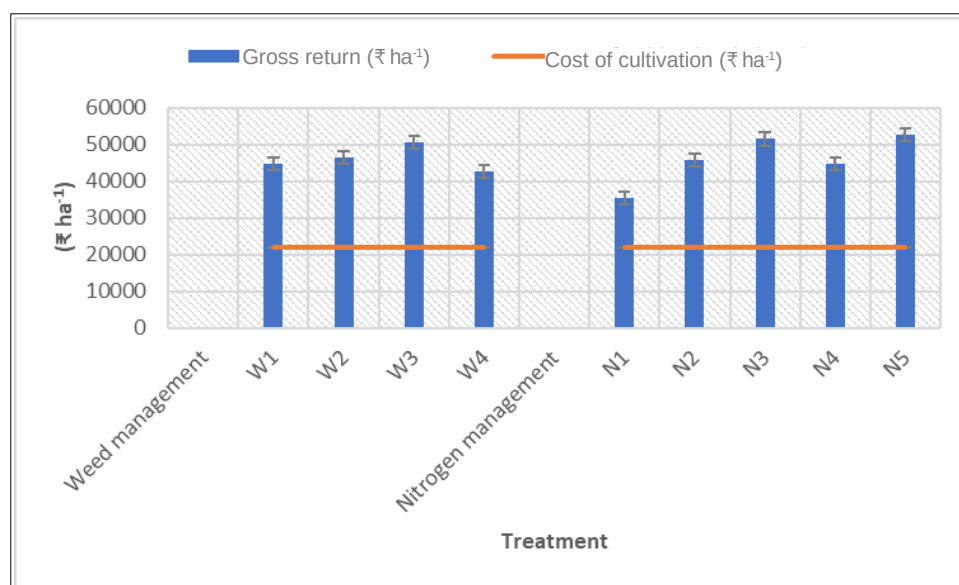


Fig. 6. Effect of weed and nitrogen management in baby corn on gross return of succeeding black gram.

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally). Vertical lines above bars indicate standard errors.

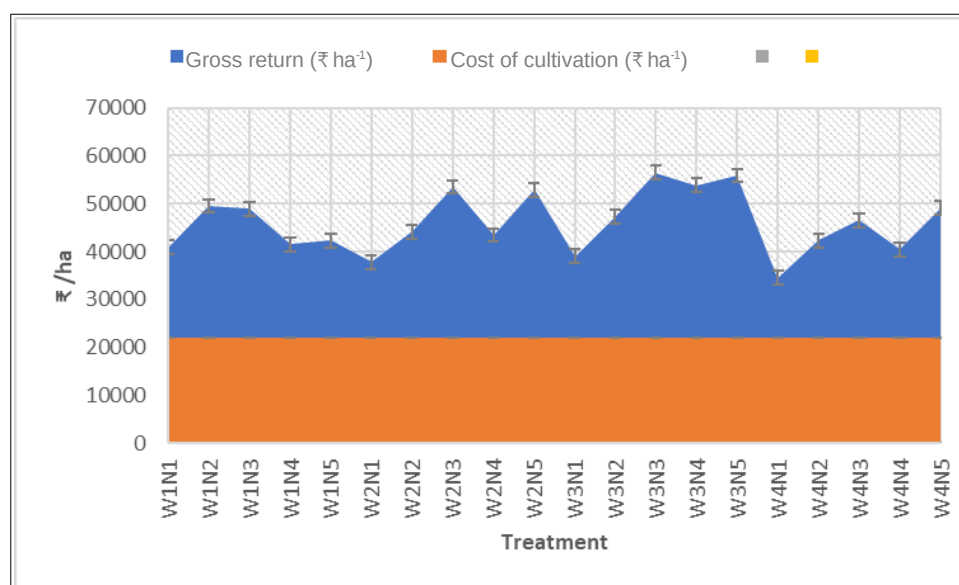


Fig. 7. Interactive effects of weed and nitrogen management in baby corn on gross return and cost of cultivation of succeeding black gram.

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally). Vertical lines above the top indicate standard errors.

Table 7. Interactive effects of weed and nitrogen management in baby corn on economics of black gram (Pooled over 2022 and 2023)

Treatment	N ₁	N ₂	N ₃	N ₄	N ₅	Mean
Net return (₹ ha ⁻¹)						
W ₁	18930	27633	27008	19633	20413	22723
W ₂	15862	22192	31610	21500	30972	24427
W ₃	17106	25326	34529	31954	33966	28576
W ₄	12631	20361	24631	18500	27119	20648
Mean	16132	23878	29445	22897	28118	24094

	W	N	WN	NW		
SEm±	514	600	1190	1200		
CD ($p = 0.05$)	1583	1695	2734	3389		
Return per rupee investment						
W ₁	1.86	2.26	2.23	1.90	1.93	2.04
W ₂	1.72	2.01	2.44	1.98	2.41	2.12
W ₃	1.78	2.16	2.58	2.46	2.55	2.30
W ₄	1.58	1.93	2.12	1.84	2.24	1.94
Mean	1.74	2.09	2.34	2.05	2.28	2.10
	W	N	WN	NW		
SEm±	0.02	0.03	0.05	0.06		
CD ($p = 0.05$)	0.07	0.08	0.13	0.15		

W₁: Atrazine 1.0 kg ha⁻¹; W₂: Tembotrione + 2,4-D 90 + 400 g ha⁻¹; W₃: W₁ + Manual weeding at 21 DAS; W₄: Hoeing and weeding at 21 DAS; N₁: 100 % N (Urea); N₂: 75 % N (Urea) + 25 % N (FYM); N₃: 75 % N (Urea) + 25 % N (VC); N₄: 75 % N (Urea) + 25 % N (FYM and VC equally); N₅: 50 % N (Urea) + 50 % N (FYM and VC equally); SEm ±: Standard error of mean; CD: Critical difference; FYM: Farm yard manure; VC: Vermicompost; WN: Weed management at same or different level of N; NW: Nitrogen management at same level of weed management.

Table 8. Correlogram showing correlation among crop and weed parameters of black gram

	PH	BP	LAI	DMP	PP	SP	SY	HY	WD	WB
PH	1.000									
BP	0.425	1.000								
LAI	0.232	0.391	1.000							
DMP	0.793	0.500	0.211	1.000						
PP	0.681	0.429	0.445	0.805	1.000					
SP	0.738	0.488	0.426	0.777	0.917	1.000				
SY	-0.053	0.293	0.406	0.325	0.477	0.372	1.000			
HY	0.106	0.577	0.367	0.492	0.535	0.497	0.888	1.000		
WD	0.453	0.367	0.364	0.165	0.055	0.192	-0.539	-0.320	1.000	
WB	0.308	0.256	0.216	0.025	-0.130	0.029	-0.595	-0.374	0.871	1.000

PH: Plant height (cm) at physiological maturity; BP: Branches per plant at physiological maturity; LAI: Leaf area index at 60 DAS; DMP: Dry matter production at physiological maturity (g m⁻²); PP: Pods per plant; SP: Seeds per pod; SY: Grain yield (kg ha⁻¹); HY: Haulm yield (kg ha⁻¹); NR: Net return (₹ha⁻¹); WD: Weed density (Number per 0.25 m²); WB: Weed biomass (g per 0.25 m²); r₅ % at 18 degree of freedom: 0.444; r₁ % at 18 degree of freedom: 0.561.

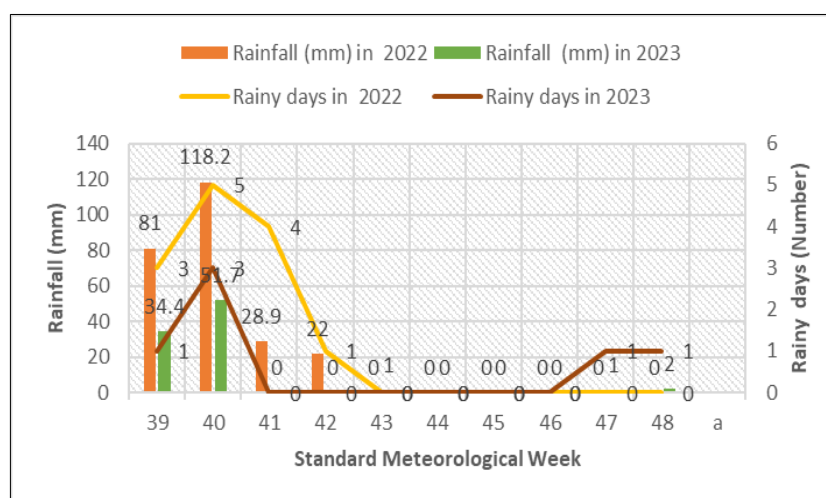


Fig. 8. Weekly rainfall and rainy days during growth period of black gram.

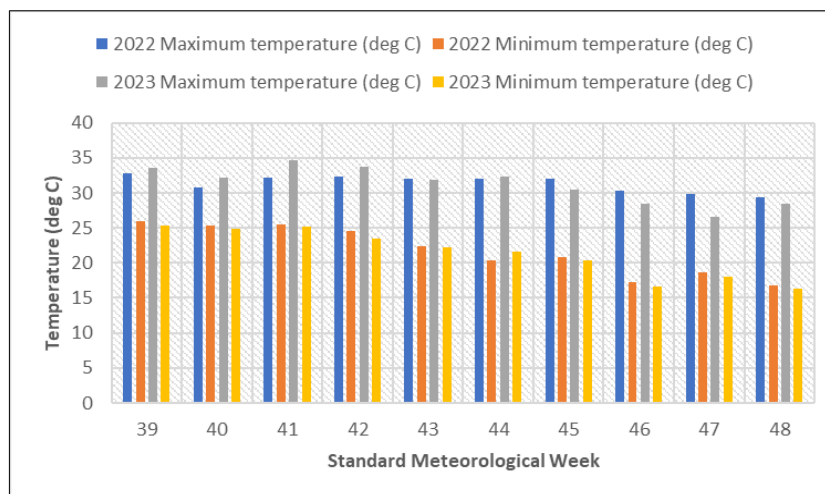


Fig. 9. Weekly maximum and minimum temperature (°C) during growth period of black gram.

Weed infestation

The lower weed density and biomass in black gram after application of atrazine followed by manual weeding in baby corn was due to early weed management by herbicide component and elimination of subsequent flush of weeds by manual weeding. The lower weed density observed in the succeeding black gram crop suggests that integrated weed management effectively depleted the soil weed seed bank during the baby corn season, reducing weed emergence in the following crop. Atrazine is highly effective in reducing soil weed seed bank (12). Debit from weed seed bank minimised weed menace in succeeding crops (12, 13). The maximum weed density and biomass under 50 % STBN (urea) + 25 % STBN (FYM) + 25 % STBN (VC) could be due to addition of weed seeds to soil through FYM applied to preceding baby corn and carryover effect on black gram.

Crop growth

The absence of phytotoxic effects indicates that the herbicides were degraded sufficiently before establishment of black gram, consistent with previous reports under warm and moist tropical conditions. No phytotoxic effects of these herbicides were recorded on black gram. Chemical and microbial degradation of these herbicides were faster under warm and moist weather prevailing in the season. Degradation of atrazine is faster under higher temperature with application of NPK fertilisers (29). Earlier studies revealed that atrazine and tembotrione applied to preceding maize had no phytotoxicity effects on black gram (30). There is negative correlation of tembotrione persistence with organic carbon, temperature and moisture regime and half-life of the herbicide at 35 °C is only 15.7 days (31). Application of 2,4-D ethyl ester in wheat had no phyto-toxicity on succeeding black gram (32). The superiority of residual effects of atrazine + hand weeding applied in baby corn on plant height, branches per plant, LAI, number of nodules and weight per plant and CGR of black gram was due to season long and satisfactory weed control in baby corn that ensured relatively weed free plot for the succeeding crop. The minimum plant height and branches per plant, LAI, dry matter accumulation, nodule

number and weight per plant and CGR in black gram with 100 % N through urea could be attributed to rapid mineralisation, greater availability and higher uptake of nitrogen by the preceding baby corn, loss due to leaching and lower retention in post-harvest soil. The higher values of growth parameters under INM than inorganic source can be attributed to slow and steady release from organic sources, reduced leaching loss, lower uptake by the preceding crop and higher carry over nitrogen for use by the succeeding black gram, because organic sources leave higher amount of nutrients in post-harvest soil for use by the succeeding crop (20). Higher residual N under INM practices facilitates enhanced protein synthesis by succeeding black gram which was manifested in form of superior growth parameters. Taller plants of green gram were reported with application of 75 % RDN (Chemical) + 50 % RDN (FYM) + 25 % RDN (VC) than RDN alone to preceding baby corn (19).

Yield and yield attributes

Better yield attributes of black gram with application of atrazine 1.0 kg ha⁻¹ + one manual weeding in baby corn can be attributed to withdrawal of seed from soil weed seed bank, reduced weed density and biomass, higher dry matter accumulation and efficient partitioning of photosynthates to reproductive parts in black gram. Improved weed control enhanced assimilate partitioning towards reproductive growth, resulting in greater pod production and higher grain yield. The lower grain and haulm yield under 100 % STBN (urea) may be attributed to greater nitrogen uptake by baby corn, increased nitrogen losses from the soil through leaching and denitrification and consequently lower residual nitrogen availability for uptake by the succeeding black gram crop, which is consistent with previous findings. Earlier research works revealed that application of inorganic fertiliser (150 : 60 : 60 kg ha⁻¹ N-P₂O₅-K₂O) in baby corn gave the maximum yield of baby corn, whereas application of equal proportion of organic and inorganic (50 : 50) sources in baby corn gave the maximum yield of succeeding rice (16). Similar improvements in residual crop productivity following integrated nutrient management have been reported in several maize-based

cropping systems (19). The maximum dry matter production under the treatment contributed to the maximum haulm yield.

Economics

The weed and nitrogen management practices in baby corn exhibited the similar trend for yield, gross return and net return of black gram. Higher economic returns primarily resulted from increased grain and haulm yields achieved under integrated weed and nutrient management. Cost of cultivation under all the treatments was the same (Fig. 8), as no treatment was imposed in black gram. The crop was raised with recommended package of practices. The maximum gross return, net return and B : C under atrazine + one hand weeding was due to reduced weed pressure on black gram and higher yield of grain and haulm. Earlier research revealed that atrazine + one hand weeding in kharif maize resulted in the maximum system yield and net return from maize-wheat sequence cropping system (33). The minimum gross return, net return and B : C under STBN through urea alone and higher values under integrated nitrogen management practices (W_3N_3 , W_3N_5) may be attributed to better microbial activity and soil structure, retention of higher soil moisture and higher carry over nitrogen for use by black gram leading to higher grain and haulm yield and higher economic returns. Previous studies demonstrated that integrated nutrient management in maize resulted in higher net return and B : C of the succeeding crops (34). The highest gross return (₹56433 ha⁻¹), net return (₹34529 ha⁻¹) and return per rupee invested (2.58) with integrated weed management combined with N_3 and statistical parity with W_3N_5 and W_3N_4 underscored the significance of integrated weed and nitrogen management in improving economics indices.

Correlation studies

The significant positive correlation of grain yield with pods per plant and haulm yield and haulm yield with branches per plant, dry matter production at 60 DAS, pods per plant, seeds per pod and grain yield revealed the traits contributing to yield of grain and haulm respectively, in black gram grown after baby corn. The significant negative correlation between yield and weed indices established weed growth as a hindrance to performance of black gram.

4. Conclusion

Integrated weed and nitrogen management in baby corn produced favourable residual effects on the growth, yield and profitability of the succeeding black gram crop. Integrated weed management comprising atrazine followed by manual weeding in baby corn could reduce weed density and biomass in black gram. Substitution of soil test-based nitrogen with FYM and vermicompost in baby corn favoured growth and development of black gram. Among the tested treatments, atrazine followed by manual weeding combined with 75 % STBN through

urea and 25 % STBN through vermicompost, 50 % STBN through urea, 25 % STBN through FYM and 25 % STBN through vermicompost and 75 % STBN through urea, 12.5 % STBN through FYM and 12.5 % STBN through vermicompost produced higher grain yield and economic return than other treatments. These integrated management strategies offer sustainable approach for improving productivity and profitability in rainfed baby corn-black gram cropping systems.

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Authors' contributions

AM carried out the field experimentation, data collection and manuscript preparation. BB planned and monitored the experiment and reviewed the manuscript. SDB conducted statistical analysis. MR helped in data recording. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest

Authors do not have any conflict of interests to declare.

Ethical issues

None

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