Enhancing Blackgram Yield through Optimized Irrigation Scheduling and Integrated Nutrient Management: Growth Characteristics and Yield Components

Abstract

A field experiment was carried out at Soil Conservation and Water Management Farm of C S Azad University of Agriculture and Technology, Kanpur during *Zaid seasons* i.e. 2022 and 2023 to assess the effect of irrigation scheduling and integrated nutrient management on blackgram.The experiment consisted of three irrigation schedules*viz*.I_1:0.4 IW/CPE, I_2:0.6 IW/CPE, I_3:0.8 IW/CPE, along with five integrated nutrient management options *viz*.F_1: 100% RDF, F_2:125% RDF.F_3: 75% RDF + 2.5 ton FYM/ha,F_4: 50 % RDF + 5 ton FYM/ha.F_5: 50% RDF + 2.5 ton FYM/ha + 1 tonvermi-compost. The experiment was conducted in Split Plot Design replicated thrice irrigation scheduling systems in main plots and integrated nutrient managementin sub plots. The result clearly revealed thatsignificantly higher growth attributes *viz*plant height (35.25 cmand 37.56 cm), number of branches plant^{-1}(8.87 and 9.21), number of plant leaves (19.96 and 20.29) at harvest and yield attributes *viz* number of pod per plant (27.80 and 30.10) no of seed per pod (6.62 and 6.91) and also higher seed yield (9.30 q ha^{-1} and 9.90 qha^{-1}), stover yield(23.21 q ha^{-1} and 24.03 q ha^{-1}) were recorded with I_3: 0.8 IW/CPE compared to I_1: 0.4 IW/CPE and I_2: 0.6 IW/CPE. Among the integrated nutrient management significantly higher growth attributes *viz* plant height (36.12 cm and 38.07 cm), number of branches plant^{-1} (9.01 and 9.32), number of plant leaves (20.05 and 20.45) at harvest and yield attributes *viz* number of pod per plant (28.44 and 30.17) no of seed per pod (7.05 and 7.37) and also higher grain yield (9.73 q ha^{-1} and 10.27 qha^{-1}), stover yield(23.55 q ha^{-1} and 24.76 q ha^{-1}) were recorded with F_5:50% RDF + 2.5 ton FYM/ha + 1 ton vermi-compost as compared to other integrated nutrient management protocol.

***Keywords*:** IW/CPE, Vermi-compost, FYM, Yield**.**

1.INTRODUCTION

Pulses are given second importance after cereals and pulses crop is rich in protein, fibers, vitamins, and minerals such as magnesium, iron, and zinc and low in fat, making them a great addition to any diet that plays a very important role in the diet of humans, especially in Indian people which are not able to supply their body protein due to being vegetarian. By holding atmospheric nitrogen in the root nodules, they keep the soil fruitful and healthy. India has a ubiquitous position as the leading producer, the foremost consumer, and the largest importer of

pulses. Pulses can be grown on a range of soil and climatic conditions and play an important role in crop rotation, mixed and inter-cropping, maintaining soil fertility through nitrogen fixation, releasing soil-bound phosphorus, and thus contributing significantly to the sustainability of the farming system. In the northern part of the country, black gram is grown in *kharif* or *summer* only while in the eastern and southern parts of India it grows in the *rabi* season also and sometimes grows as a green manuring crop.

"India is its primary origin and mainly cultivated in Asian countries including Pakistan, Myanmar, and parts of Southern Asia. About 70 percent of the world's black gram production comes from India. India is the world's largest producer as well as consumer of black gram. Our country produces about 24.5 lakh tonnes of Urd bean annually from about 4.6 million hectares of area, with an average productivity of 533 kg per hectare in 2020-21" (Anonymous, 2020) [3]. Black gram area accounts for about 19 percent of India's total pulse acreage which contributes 23 percent of total pulse production. It is mostly grown as rain-fed during *Kharif* and *summer* in Northern India

" Irrigation scheduling is one of the factors that influence the agronomic and economic viability of small farms. It is important for both water savings and improved crop yields point of view. Scientific irrigation scheduling should go with an understanding of the soil-water-plant-atmosphere continuum. Irrigation water economy can be aimed through appropriate irrigation schedules and meteorological approaches based on pan evaporation is one of the simplest, most reliable, economical, and least time-consuming methods. The loss of water through evapotranspiration, and leaching, can be minimized by scheduling irrigation. Water is not available in adequate quantities in the summer season, it limits crop production. One scientific method in the area is (IW: CPE Ratios) approach for scheduling of irrigation. Water use in agricultural production as one of the most important environmental factors affecting plant growth and development" (Mirzaei *et al*., 2005) [10]. "Productivity response to water stress is different for each crop and is expected to vary with the climate" (AbdzadGohari, 2013) [1].

"The integrated nutrient management ensures higher productivity, minimizes expenditure on costly fertilizer inputs, improves physical properties of soil, efficiency of added nutrients and at the same time ensures good soil health and is also an environment- friendly approach" (Singh and Singh, 2017)[16]. It comprises of application of organic manures, green manures, bio-fertilizer and crop rotation with legumes along with minimum use of chemical fertilizer to produce optimum crop yields without deteriorating the soil health.

2. MATERIALS AND METHODS

Experimental Location:

The research was conducted at the Soil Conservation and Water Management Farm, affiliated with Chandra Shakher Azad University of Agriculture and Technology, Kanpur. The study site was geographically situated between 25°26' and 26°58' North latitude and 79°31' and 80°34' East longitude.

Experimental Period:

The experimental investigation was carried out during the Zaid season of the year 2022 and 2023.

Experimental Design:

A Split Plot Design was employed to explore the effects of various irrigation schedules and integrated nutrient management practices on the growth and yield of blackgram (variety : Shekhar-2) This design included three replications to ensure the robustness of the results.

Irrigation Schedules:

Three distinct irrigation schedules were employed as the primary treatment variables:

1. I_1: 0.4 IW/CPE (Irrigation Water to Cumulative Pan Evaporation)
2. I_2: 0.6 IW/CPE
3. I_3: 0.8 IW/CPE

Integrated Nutrient Management Options:

Five integrated nutrient management options were tested, serving as secondary treatment variables:

1. F_1: 100% Recommended Dose of Fertilizers (RDF)
2. F_2: 125% RDF
3. F_3: 75% RDF + 2.5 tons of Farm Yard Manure (FYM) per hectare
4. F_4: 50% RDF + 5 tons of FYM per hectare
5. F_5: 50% RDF + 2.5 tons of FYM per hectare + 1 ton of vermicompost

Soil Characteristics:

The soil at the experimental site was classified as sandy loam, and it possessed the following initial soil properties:

- Organic Carbon Content: 0.33%

- Available Nitrogen (N): 0.03%

- Available Phosphorus (P2O5): 17.85 kg/ha

- Available Potassium (K2O): 131.30 kg/ha

Crop Management:

The blackgram variety Shekhar-2 was selected for this study. It was sown in the second fortnight of March and harvested during the first fortnight of June in both consecutive years of the experiment.

Data Analysis:

Collected data were subjected to rigorous statistical analysis to assess the impact of different irrigation schedules and integrated nutrient management practices on the growth and yield of blackgram in the unique agro-climatic conditions of the study area. Statistical methods such as Analysis of Variance (ANOVA) and Tukey's multiple comparison test were employed to determine significant differences among treatment groups.

3. RESULT

3.1*Growth characteristics*

The growth attributes of Blackgram as influenced by irrigation scheduling and integrated nutrient management. The data in table 1 showed that growth parameters *viz*., plant height, number of branches plant^{-1} and number of plant leaves were recorded significantly heights by the irrigation scheduling at I_3: 0.8 IW/CPE followed by I_2: 0.6 IW/CPE. Higher plant height (35.25 cm and 37.56 cm) in both year. "Might be due to adequate and timely supply of irrigation water at 0.8 IW/CPE which provided better nourishment and enhanced the metabolic process in the plant and promoted the cell division and cell expansion and thereby stem elongation which virtually increased the plant growth in terms of plant height Similar result was found by Singh *et al* (2018) [17] and Patel *et al* (2020)[12]. Higher number of branches plant^{-1} (8.87 and 9.21) in both years, might be due to availability of optimum moisture contributed to effective absorption and utilization of nutrients and better proliferation of roots resulting in better branches plant^{-1}.These results were in conformity with the findings of Patel *et al* (2020) [12]..Higher number of plant leaves (19.96 and 20.29) each year this is because of the accelerated vegetative growth resulted in an extensive photosynthetic apparatus and relative increase was recorded in plant leaves. Similar results were found by Patel *et al* (2016) [11] and Patel *et al* (2020)

The data in table 1 showed that higher plant height (36.12 cm and 38.07 cm), number of branches plant^{-1} (9.01 and 9.32), number of plant leaves (20.05 and 20.45) in both years recorded highest in F_5: 50% RDF + 2.5 ton FYM/ha + 1 ton vermi-compost as compared to F_1: 100% RDF, F_2: 125% RDF. F_3: 75% RDF + 2.5 ton FYM/ha, and F_4: 50 % RDF + 5 ton FYM/ha. This was because of availability of nutrients under the treatment receiving organic sources

supplemented with vermicompost. These results are also in agreement with the finding Vitnor*et al* (2015)[18]and Singh *et al* (2017) [15]

3.2*yield components*

The yield attributes of blackgram as influenced by irrigation scheduling and integrated nutrient management. The data in table 2 showed that yield parameter *viz* number of pod per plant (27.80 and 30.10) number of seed per pod (6.62 and 6.91) were significantly highest by the irrigation scheduling at I_3: 0.8 IW/CPE followed by I_2: 0.6 IW/CPE.This might be due to maintenance of optimum soil moisture condition which affected the root nodulation as well as availability of different nutrients, further adequate availability of moisture at all stages of crop growth and development leading to high water potential, stomatal conductance, higher photosynthesis, partitioning of photosynthates to sink consequently increasing pods per plant and number of seed per pod. This is in conformity with the result of Yadav and Singh (2014) [19], Shirgapur and fatima(2018) [14] and Patel *et al* (2022) [13].

The data in the table 2 showed that higher number of pod per plant (28.44 and 30.17) and number of seed per pod (7.05 and 7.37) in both years were recorded significantly highest in F_5: 50% RDF + 2.5 ton FYM/ha + 1 ton vermi-compost as compared to F_1: 100% RDF, F_2: 125% RDF. F_3: 75% RDF + 2.5 ton FYM/ha, and F_4: 50 % RDF + 5 ton FYM/ha. This was because of availability of nutrients under the treatment receiving organic sources supplemented with Vermicompost. Similar results were found by De *et al* (2011) [6] and Meena *et al* (2019) [8].

3.3*Yield*

The yield parameters of blackgram as influenced by irrigation scheduling and integrated nutrient management. The data in table 3 showed that yield parameter viz., grain yield (9.73 q ha^{-1} and 10.27 qha^{-1}), and stover yield(23.55 q ha^{-1} and 24.76 q ha^{-1}) were significantly highest by the irrigation scheduling at I_3: 0.8 IW/CPE followed by I_2: 0.6 IW/CPE.This might be due to maintenance of optimum soil moisture condition which affected the root nodulation as well as availability of different nutrients, further adequate availability of moisture at all stages of crop growth, higher vegetative growth and development leading to high water potential, stomatal conductance, higher photosynthesis, partitioning of photosynthates to sink consequently increasing grain yield and stover yield. This result also confirms the finding Chavan *et al* (2014) [4], Kumar *et al* (2015) [7] and Shirgapur and fatima (2018)[14]

The data in table 3 showed that higher grain yield (9.73 q ha^{-1} and 10.27 qha^{-1}), and stoveryield (23.55 q ha^{-1} and 24.76 q ha^{-1}) in both years recorded highest in F_5: 50% RDF + 2.5 ton FYM/ha + 1 ton vermi-compost as compared to F_1: 100% RDF, F_2: 125% RDF. F_3: 75% RDF + 2.5 ton FYM/ha, and F_4: 50 % RDF + 5 ton FYM/ha. This was because of availability of nutrients under the treatment receiving organic sources supplemented with vermicompost. This is in conformity with the result ofAbhilasha*et al* (2022) [2],Danga*et al (*2022) [5] and Meera *et al* (2022) [9].

4. Discussion

In our study, we examined the impact of irrigation scheduling and integrated nutrient management on the growth and yield of blackgram. Here, we discuss the key findings in a concise manner.

Growth Characteristics:

- **Irrigation Scheduling:** The results show that the highest plant height, number of branches per plant, and number of leaves were achieved with the I_3 irrigation schedule (0.8 IW/CPE). This suggests that adequate and timely irrigation positively influenced blackgram growth.
- **Integrated Nutrient Management:** The treatment involving F_5 (50% RDF + 2.5 ton FYM/ha + 1 ton vermi-compost) produced the tallest plants with the most branches and leaves. This outcome highlights the importance of organic sources supplemented with vermicompost for robust blackgram growth.

Yield Components:

- **Irrigation Scheduling:** The I_3 irrigation schedule resulted in the highest number of pods per plant and seeds per pod. Consistent moisture throughout the growth stages positively impacted pod and seed formation.
- **Integrated Nutrient Management:** Once again, the F_5 treatment showed the highest number of pods per plant and seeds per pod. The inclusion of vermicompost in nutrient management contributed to this positive effect on yield components.

Yield:

- **Irrigation Scheduling:** The I_3 irrigation schedule led to the highest grain and stover yields. Maintaining optimal soil moisture conditions promoted root development, photosynthesis, and ultimately, higher yields.
- **Integrated Nutrient Management:** The F_5 treatment also resulted in the highest grain and stover yields. The combination of organic sources and vermicompost enhanced nutrient availability, further boosting yields.

Table 1The effect of irrigation scheduling and integrated nutrient management on growth of urdbean.

Treatments	Plant height (cm)			No. of branches per plant			No. of Plant leaves		
	At Maturity			At Maturity			At Maturity		
	2022	2022	2022	2022	2023	Pooled	2022	2023	Pooled
Irrigation Scheduling-									
I_1 - 0.4 IW/CPE.	31.51	32.44	31.975	5.88	6.43	6.155	17.17	17.38	17.275
I_2 - 0.6 IW/CPE.	34.54	36.18	35.36	8.42	8.83	8.625	18.98	19.25	19.115
I_3 -0.8 IW/CPE.	35.25	37.56	36.40	8.87	9.21	9.04	19.96	20.29	20.125
Se(d)	0.55	0.43	0.49	0.11	0.12	0.115	0.24	0.26	0.25

CD at 5 %	1.58	1.25	1.415	0.33	0.36	0.345	0.68	0.75	0.715
Integrated nutrient management									
F_1 - 100% RDF.	31.49	32.76	32.125	6.83	7.04	6.935	17.90	17.95	17.925
F_2 - 125% RDF.	32.84	33.92	33.38	7.00	7.31	7.155	18.09	18.12	18.105
F_3 -75% RDF + 2.5 t FYM/ha.	33.81	35.46	34.635	7.48	8.29	7.885	18.47	18.92	18.695
F_4 - 50% RDF + 5.0 t FYM/ ha.	34.57	36.77	35.67	8.30	8.82	8.56	19.01	19.44	19.225
F_5 -50% RDF + 2.5 t FYM/ha + 1 t Vermicompost.	36.12	38.07	37.095	9.01	9.32	9.165	20.05	20.45	20.25
Se(d)	0.76	0.49	0.625	0.18	0.20	0.19	0.43	0.43	0.43
CD at 5%	1.59	1.03	1.31	0.37	0.42	0.395	0.89	0.91	0.9

Table 2 The effect of irrigation scheduling and integrated nutrient management on the Yield attributing character of urdbean.

Treatments	**Yield attributing character**					
	Number of pods per plant			**Number of seeds per plant**		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
Irrigation Scheduling-						
I_1 - 0.4 IW/CPE.	21.70	23.11	22.405	4.81	5.23	5.02
I_2 - 0.6 IW/CPE.	26.33	28.30	27.315	6.10	6.41	6.255
I_3 -0.8 IW/CPE.	27.80	30.10	28.95	6.62	6.91	6.765
Se(d)	0.36	0.40	0.38	0.08	0.09	0.085

CD at 5 %	1.04	1.14	1.09	0.24	0.27	0.255
Integrated nutrient management						
F_1 - 100% RDF.	22.75	24.20	23.475	4.99	5.22	5.105
F_2 - 125% RDF.	23.68	25.19	24.435	5.22	5.37	5.295
F_3 -75% RDF + 2.5 t FYM/ha.	24.77	27.47	26.12	5.62	5.92	5.77
F_4 - 50% RDF + 5.0 t FYM/ ha.	26.76	28.81	27.785	6.34	7.04	6.69
F_5 -50% RDF + 2.5 t FYM/ha + 1 t Vermicompost.	28.44	30.17	29.305	7.05	7.37	7.21
Se(d)	0.59	0.63	0.61	0.13	0.14	0.135
CD at 5%	1.22	1.31	1.265	0.28	0.30	0.29

Table 3The effect of irrigation scheduling and integrated nutrient management on yield of urdbean.

Treatments	**YIELD**					
	Seed yield(q/ha)			**Stover yield**		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
IRRIGATION SCHEDULIN-						
I_1 - 0.4 IW/CPE.	6.83	7.00	6.91	20.25	21.00	20.62
I_2 - 0.6 IW/CPE.	8.59	9.17	8.88	22.79	23.54	23.16
I_3 -0.8 IW/CPE.	9.30	9.90	9.60	23.21	24.03	23.62
Se(d)	0.30	0.29	0.29	0.57	0.48	0.52
CD at 5 %	0.87	0.83	0.85	1.62	1.37	1.49
Integrated nutrient management						

F_1 - 100% RDF.	7.18	7.40	7.29	20.14	21.01	20.57
F_2 - 125% RDF.	7.49	7.74	7.61	21.21	21.72	21.46
F_3 -75% RDF + 2.5 t FYM/ha.	7.98	8.57	8.27	22.54	22.94	22.74
F_4 - 50% RDF + 5.0 t FYM/ ha.	8.82	9.47	9.14	22.97	23.86	23.41
F_5 -50% RDF + 2.5 t FYM/ha + 1 t Vermicompost.	9.73	10.27	10.00	23.55	24.76	24.15
Se(d)	0.36	0.37	0.36	0.60	0.62	0.61
CD at 5%	0.75	0.77	0.76	1.24	1.29	1.26

5. Conclusion

Our research explored the combined effects of irrigation scheduling and integrated nutrient management on the growth, yield components, and overall yield of blackgram (variety: Shekhar-2) during the Zaid season.

From the results obtained, several key conclusions can be drawn:

1. Optimal Irrigation Scheduling: Adequate and timely irrigation, specifically at the rate of 0.8 IW/CPE (I_3), significantly improved blackgram growth attributes, including plant height, the number of branches per plant, and the number of leaves. Consistent soil moisture levels throughout the growth stages promoted robust vegetative growth and enhanced yield components.

2. Integrated Nutrient Management: The incorporation of organic sources, particularly the treatment involving 50% RDF + 2.5 ton FYM/ha + 1 ton vermicompost (F_5), had a substantial positive impact on blackgram growth and yield. This treatment consistently outperformed others, resulting in taller plants, increased branching, more leaves, and higher yield components.

3. Synergy between Irrigation and Nutrient Management: The combination of optimal irrigation scheduling (I_3) and integrated nutrient management (F_5) proved to be particularly effective, resulting in the highest grain and stover yields. This synergy highlights the importance of aligning irrigation and nutrient management practices for enhanced blackgram production.

4. Validation of Prior Research: Our findings align with previous research that has emphasized the significance of proper irrigation and the inclusion of organic sources, such as

vermicompost, in nutrient management. This reinforces the relevance and applicability of our results to practical blackgram cultivation.

In conclusion, study provides valuable insights for blackgram growers and agricultural practitioners. By adopting suitable irrigation schedules and integrating organic nutrient sources, blackgram cultivation can be optimized, leading to increased growth, improved yield components, and ultimately higher grain and stover yields. These findings contribute to sustainable and efficient crop management practices, ensuring food security and economic stability in similar agro-climatic conditions.

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