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Synergistic effects of integrated nitrogen management on physiological and morphological growth traits in chickpea (*Cicer arietinum* L.) varieties

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Abstract
The investigation was carried out on influence of integrated nitrogen management on growth attributes of chickpea (*Cicer arietinum* L.) Varieties field experiment was conducted at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. Experimental design involved a split-plot arrangement with four chickpea varieties as the main plots and four nitrogen management strategies (100% organic, integrated (50% organic + inorganic), integrated (75% organic + 25% inorganic) and 100% inorganic (recommended dose of fertilizer, RDF) as sub—plots, with three replications. The findings revealed that the chickpea variety GNG 1581 exhibited significantly higher plant height dry matter accumulation crop growth rate (CGR) relative growth rate (RGR) number of nodules plant^{-} number of branches plant^{-1} and SPAD chlorophyll meter reading, statistically at par with GNC 2144 to Of varieties. Among the nitrogen management the integrated application of 50% organic and 50% inorganic sources resulted in the highest plant height dry matter accumulation crop growth rate (CGR) relative growth rate (RGR) number of nodules plant^{-} number of branches plant^{-1} and SPAD chlorophyll meter reading, although it was statistically on par with the 100% inorganic RDF treatment. These results outperformed both the 100% organic and the 75% organic 25% inorganic treatments.

Keywords: Chickpea, integrated nitrogen management, organic and inorganic fertilizers, growth attributes, dry matter accumulation, chickpea varieties

Introduction
Chickpea (*Cicer arietinum* L.) belongs to the genus *Cicer*, tribe *Cicereae*, family *fabaceae* and sub-family *Papilionaceae*. It contains 17-21% protein, 62% carbohydrates, 4% fat and minerals such as calcium, phosphorus, zinc, iron and magnesium (Diapari *et al.*, 2014) [4]. Being a good source of protein and minerals, it is regarded as poor man's meat in low-income countries and healthy food in the developed world. It is mostly consumed in the form of processed whole seed (boiled, roasted, parched, fried, steamed, sprouted etc.) or dal or as gram flour (Besan). It is used in preparing a variety of snacks, sweets and condiments and also mixed with wheat flour for "chapati'' making. Fresh green seeds, dry seed and green leaves are consumed as green vegetables.

In recent years, significant progress has been made in the development of high-yielding genotypes of chickpea varieties. The numerous researches conducted across various regions of the country have underscored the importance of proper nutrient supplementation for these varieties to fully express their inherent genetic potential in producing optimal yield and nutritional quality. Further, studies investigating genetic variability in chickpea germplasm have revealed a significant range of genetic variation for zinc content and demonstrate the substantial response of chickpea varieties to increased levels of micro-nutrient's critical role in enhancing yield and quality (IIPR, 2022-23) [5].

The increased use of chemical fertilizers in agriculture has certainly enhanced the food production but brought with it a lot of problems related to micronutrient deficiency and environmental pollution (Murphy *et al.*, 2007) [8]. This alarming situation itself has emphasized the importance of organic manures in agriculture. A sudden reversion to organic farming cannot satisfy both the hungry soil and the ever growing population. Organic manures have become

scarce and green manuring seems to be infeasible under intensive agriculture. Therefore, integrated nutrient management could be quite promising in maintaining higher productivity and providing greater stability in crop production (Kumar *et al.*, 2019) [6].

Materials and Methods

The study was carried out during the Rabi season at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Maharana PratapUniversity of Agriculture and Technology, Udaipur,Rajasthan, India. The experimental design in corpo rated four chickpea varieties GNG 1581, GNG 2144, GNG 2171 and JG 16 in the main plots. The subplots were assigned to four integrated nitrogen management treatments: N 1-100% nitrogen supplied through organic manure, N2- 50% nitrogen from organic manure and 500/0 from chemical fertilizers, N3- 75% nitrogen from organic manure and 25% from chemical fertilizers and N4 — 100% of the RDF supplied through chemical fertilizers. Vermicompost was used as the organic manure, while urea and single super phosphate were utilized as chemical fertilizer respectively.

Observation recorded

Growth Characters

- Plant height at 30, 60, 90 DAS and at harvest
- Dry matter accumulation at 30, 60, 90 DAS and at harvest
- Crop growth rate (CGR) between 30-60 and 60-90 DAS

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

Where,
W_1 and W_2 are dry weight in g m^{-1} row length at time t_1 and t_2, respectively. P represents the ground area.

Relative growth rate (RGR)

$$RGR\ (g\ g^{-1}\ day^{-1}) = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where,
W_1 and W_2 are dry weight in g m^{-1} row length at time t_1 and t_2, respectively

- **Number of nodules plant^{-1}** at 30, 60 and 90 DAS
- **Number of branches plant^{-1}** at 60, 90 DAS and at harvest
- **SPAD chlorophyll meter reading** the help of SPAD Chlorophyll meter (SPAD-502)

Results

Plant height

The data on various growth parameters of chickpea varieties under the influence of integrated nitrogen management practices at 30, 60, 90 DAS and at harvest.

Varieties

Chickpea varieties caused significant influence on plant height at 60,90 DAS and at harvest during both the years of investigation as well as in pooled analysis. The chickpea variety GNG 1581 recorded highest plant height which was found at par with variety GNG 2144 and both these varieties significantly enhanced plant height over rest of varieties during both years. Both the years of experimentation as well as in pooled analysis the chickpea variety GNG 1581 attained highest plant height at 60, 90 and harvest. On pooled basis, chickpea variety GNG 1581 and GNG 2144 significantly improved plant height at 60 DAS by 3.05 and 5.83 cm, at 90 DAS by 4.51 and 8.52 cm and at harvest 57.70 and 57.18 cm compared to variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

Integrated nitrogen management practices facilitated chickpea crop to attain significantly higher plant height at 60,90 DAS and at harvest during both the years of study as well as in pooled analysis. Application of 100% N through organic manure and 75% N through organic manure + 25% N through chemical fertilizer failed to record perceptible variation in this regard during either year of research. The crop fertilized with 50% N through organic manure + 50% N through chemical fertilizer resulted maximum plant height which was statistically at par with the application of 100% RDF through chemical fertilizer but both these practices proved significantly superior over rest of treatments during both years. Pooled results indicate that application of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer significantly improved plant height at 60 DAS by 2.59 and 4.75, at 90 DAS by 4.00 and 3.47 and at harvest by 3.38 and 6.52 cm over application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure, respectively.

Dry matter accumulation

Varieties

Chickpea varieties differed significantly with respect to dry matter accumulation m^{-2} at 60 DAS during both the years of experimentation as well as in pooled analysis. The chickpea variety GNG 1581 accumulated highest dry matter m^{-2}, which was found at par with variety GNG 2144 and both these varieties, recorded significantly higher dry matter accumulation m^{-2} over rest of varieties during both years. The mean of two years indicate that chickpea variety GNG 1581 and GNG 2144 significantly improved dry matter accumulation m^{-2} at 60 DAS by 12.33 and 25.87 per cent, at 90 DAS by 8.50 and 18.13 per cent and at harvest 7.82, 16.14 per cent over variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

Application of recommended dose of nitrogen through any source to chickpea crop significantly improved DMA m^{-2} at 90 DAS during both the years of investigation as well as in pooled analysis. Application of 50% N through organic manure + 50% N through chemical fertilizer accumulated highest amount of dry matter m^{-2} at 90 DAS which was found at par with the application of 100% RDF through chemical fertilizer however both these nitrogen management practices proved significantly superior over rest of treatments during both years. Application of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer significantly improved dry matter accumulation at 60 DAS by 9.34 and 19.61 per cent and 8.00 and 18.15 per cent at 90 DAS by 5.57, 11.68 and 5.13, 11.21 per cent at harvest 5.49 and 11.36 per cent and was 5.15 and 10.99 per cent over application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure.

Growth efficiency

Varieties

Chickpea varieties brought about significant variation on CGR estimated between 30-60 DAS during both the years of

investigation as well as pooled analysis. The chickpea variety GNG 1581 recorded highest CGR between 30-60 DAS which was found at par with variety GNG 2144 and both these varieties registered significant gain in CGR estimated between 30-60 DAS over varieties GNG 2171 and JG 16 during both years. On pooled basis, chickpea variety GNG 1581 and GNG 2144 significantly enhanced CGR estimated between 30-60 DAS by 12.67, 26.39 and 10.62, 24.23 per cent over variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

The crop fertilized with 50% N through organic manure + 50% N through chemical fertilizer estimated highest CGR between 30-60 DAS which remained at par with the application of 100% RDF through chemical fertilizer and both these nitrogen management practices significantly improved CGR between 30-60 DAS over rest of practices during both years. On pooled basis, application of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer significantly enhanced CGR between 30-60 DAS by 9.54, 20.04 and 8.14, 18.50 per cent over application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure, respectively.

Relative growth rate

Varieties

The chickpea variety GNG 1581 recorded highest RGR between 30-60 DAS which was found at par with variety GNG 2144 and both these varieties recorded significantly higher RGR between 30-60 DAS over varieties GNG 2171 and JG 16 during both years.

On pooled basis, chickpea variety GNG 1581 and GNG 2144 significantly enhanced RGR between 30-60 DAS by 2.27, 5.21 and 2.09, 5.21 per cent over variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

Among integrated nitrogen management practices, chickpea crop under the influence of 50% N through organic manure + 50% N through chemical fertilizer registered highest RGR between 30-60 DAS which remained at par with the application of 100% RDF through chemical fertilizer. The mean results of both years indicate that application of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer to chickpea crop significantly increased RGR between 30-60 by 2.09, 4.28 and 1.74, 3.92 per cent over application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure, respectively.

Number of nodules

Varieties

Significant influence on number of nodules plant^{-1} at 60 and 90 DAS during both the years of investigation as well as in pooled analysis. The chickpea variety GNG 1581 recorded highest number of nodules plant^{-1} at 60 and 90 DAS which remained at par with variety GNG 2144 and both these varieties significantly increased number of nodules plant^{-1} at 60 and 90 DAS over variety GNG 2171 and JG 16 during both years. Pooled results show that chickpea variety GNG 1581 and GNG 2144 significantly improved number of nodules plant^{-1} at 60 and 90 DAS by 9.03, 18.23 and 8.07, 17.20 per cent and10.31, 21.20 and 8.97, 19.73 per cent over variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

On pooled basis at 60 and 90 DAS, chickpea crop under the influence of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer significantly increased number of nodules plant^{-1} at 60 DAS 6.49, 12.72 and 5.63, 11.80 per cent and at 90 DAS 8.23 and 16.25 per cent and 7.05 and 14.98 per cent, compared to application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure respectively.

Number of branches

It is apparent varieties had significant influence on number of branches plant^{-1} at 60, 90 DAS at harvest during both years as well as in pooled analysis. The highest number of branches plant^{-1} were recorded with variety GNG 1581 closely followed by variety GNG 2144 however both these varieties significantly increased number of branches plant^{-1} over rest of varieties during both years.

The pooled data show that chickpea variety GNG 1581 and GNG 2144 significantly increased branches plant^{-1} at 60 DAS by 10.69, 20.25 and 7.95, 17.28 per cent and 90 DAS 9.44 and 20.04 per cent and 8.73 and 19.26 per cent at harvest 9.68, 20.22 and 8.76, 19.21 per cent over variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

Varieties

On pooled basis, chickpea crop under the influence of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer at 60, 90 DAS and at harvest, significantly increased number of branches plant^{-1} compared to application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure by at 60 DAS, 8.67, 18.00 and 7.12, 16.31 per cent at 90 DAS, 9.23 and 17.85 per cent and 7.41 and 15.88 per cent, at harvest by 8.85, 17.45 and 7.42, 15.91 per cent respectively.

SPAD chlorophyll meter reading

Varieties

SPAD chlorophyll meter reading at 60 DAS and 90 DAS during both the years of investigation as well as in pooled analysis. The chickpea variety GNG 1581 recorded higher SPAD chlorophyll meter reading which remained at par variety GNG 2144 and both these verities significantly enhanced SPAD chlorophyll meter reading over rest of varieties under test during both years. On pooled basis, chickpea variety GNG 1581 and GNG 2144 significantly increased SPAD chlorophyll meter reading at 60 DAS by 6.72, 13.81 and 6.37, 13.44 per cent at 90 DAS 7.38, 14.63 and 6.44, 13.63 per cent over variety GNG 2171 and JG 16, respectively.

Integrated nitrogen management

Amongst nitrogen management practices, application of 50% N through organic manure + 50% N through chemical fertilizer recorded highest SPAD chlorophyll meter reading which remained statistically at par with the application of 100% RDF through chemical fertilizer however both these nitrogen management practices significantly enhanced SPAD chlorophyll meter reading over rest of treatments during both years. On pooled basis, chickpea crop under the influence of 50% N through organic manure + 50% N through chemical fertilizer and 100% RDF through chemical fertilizer significantly increased SPAD chlorophyll meter reading compared to

application of 75% N through organic manure + 25% N through chemical fertilizer and 100% N through organic manure by at 60 DAS 5.58, 11.03 and 4.97, 10.39 per cent and, respectively. Further, when compared to application of application of 100% N through organic manure, crop fertilized with 75% N through organic manure + 25% N through chemical fertilizer significantly increased

Discussion

The overall growth of the varieties can be attributed to their genetic ability to utilize the resources available for their growth and external environmental factors to which these were exposed during their life cycle. The differential behavior of chickpea varieties with respect to growth parameters could be explained solely by the variation in their genetic makeup, difference in genotypic potential and adaptability of soil and climatic conditions. Each variety carries a unique set of genes that influence its growth and development. The increased chlorophyll content and branches plant^{-1} of variety GNG 1581 and GNG 2144 seem to have increased interception, absorption, and utilization of radiant energy along with better nutrition from roots. This enhancement results in higher accumulation of photosynthates and finally dry matter accumulation m^{-2} in variety GNG 1581 and GNG 2144 at various growth stages as well as at harvest. The finding of this investigation fall in line with those observed by Kumar *et al.* (2006) [7], Choudhary (2019) [3], Rani (2019) [10] and Arya (2020) [1].

Integrated nitrogen management

The positive influence of organic fertilization on growth parameters and overall growth of crop seems to be on account of its direct as well as indirect effects. The indirect effects are augmentation of microbial population and their activities (decomposition of organic matter), solubilization of insoluble phosphate alongwith greater availability of primary nutrients as well as micronutrients. Besides, it markedly influences physical properties of soil (water holding capacity, soil aggregates etc.). The direct effect relates to the uptake of humic substances or its decomposition products which influence growth and metabolic process in the plants. Experimental evidence suggests that soluble humic acids affect biochemical mechanism and processes within plant cells such as membrane permeability and transport, ATP production, chlorophyll content, photosynthesis and nucleic acid synthesis, thereby, improve overall growth and development.

Under the present investigation, profound influence of integrated nitrogen management 50% N through organic manure + 50% N through chemical fertilizer on crop growth seems to be due to improvement in nutritional environment of the plant on account of greater availability of nutrients from soil media. This is probably because 50% N substituted by organic manures and combined with chemical fertilizer released the nitrogen probably at faster rate and enriched the soil owing to providing sufficient amount of nitrogen that is essentially required for various metabolic processes The findings of this investigation fall in line with those observed by Yadav *et al.* (2017) [12] Seth and Kumar, (2018) [11]. The beneficial effect of chemical fertilizer in combination with vermicompost in chickpea crop is in close agreement with the findings of Priyanka *et al.* (2021) [9] and Chaithra *et al.* (2024) [2].

Table 1: Effect of chickpea varieties and integrated nitrogen management practices on plant height at successive growth stages

Treatments	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties												
GNG 2144	17.39	17.51	17.45	32.28	33.17	32.73	52.10	53.05	52.57	56.49	57.18	56.83
GNG 1581	18.12	18.25	18.19	32.76	34.06	33.41	52.83	53.54	53.19	57.33	57.70	57.52
GNG 2171	17.33	17.45	17.39	29.71	30.46	30.09	48.46	49.03	48.74	52.38	53.33	52.86
JG 16	17.26	17.31	17.29	26.86	27.77	27.31	44.84	45.02	44.93	47.57	49.49	48.53
S.Em.±	0.49	0.45	0.34	0.73	0.77	0.53	1.04	1.15	0.78	1.17	1.10	0.80
C.D. (P=0.05)	NS	NS	NS	2.53	2.66	1.64	3.59	4.00	2.39	4.05	3.80	2.47
Integrated nitrogen management												
Organic (100%)	17.17	17.32	17.25	27.64	28.48	28.06	45.82	46.50	46.16	49.38	50.65	50.01
Integrated (50% organic + 50% inorganic)	18.04	18.11	18.08	32.32	33.30	32.81	52.76	52.95	52.85	56.03	57.04	56.53
Integrated (75% organic + 25% inorganic)	17.29	17.37	17.33	29.72	30.71	30.22	48.48	49.23	48.85	52.76	53.53	53.15
Inorganic (100% RDF)	17.60	17.71	17.66	31.92	32.96	32.44	51.16	51.96	51.56	55.60	56.49	56.04
S.Em.±	0.48	0.33	0.29	0.71	0.75	0.52	0.89	0.91	0.64	0.95	0.96	0.68
C.D. (P=0.05)	NS	NS	NS	2.06	2.20	1.47	2.61	2.67	1.82	2.79	2.81	1.93

Table 2: Effect of chickpea varieties and integrated nitrogen management practices on dry matter accumulation at successive growth stages

Treatments	Dry matter accumulation (g m^{-2})											
	30 DAS			60 DAS			90 DAS			At harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties												
GNG 2144	5.85	5.88	5.87	329.58	337.28	333.43	449.70	457.92	453.81	537.00	542.50	539.75
GNG 1581	5.90	5.95	5.92	334.77	343.74	339.25	451.46	458.63	455.04	540.27	543.18	541.72
GNG 2171	5.77	5.85	5.81	299.44	304.59	302.01	415.98	422.79	419.38	498.94	505.84	502.39
JG 16	5.74	5.82	5.78	268.97	270.07	269.52	382.69	387.70	385.20	461.47	471.32	466.40
S.Em.±	0.14	0.14	0.10	7.31	6.81	4.99	9.50	10.13	6.95	10.82	9.95	7.35
C.D. (P=0.05)	NS	NS	NS	25.29	23.55	15.38	32.89	35.07	21.41	37.44	34.43	22.65
Integrated nitrogen management												
Organic (100%)	5.77	5.84	5.80	276.16	280.34	278.25	399.51	399.87	399.69	476.91	481.34	479.12
Integrated (50% organic + 50% inorganic)	5.86	5.91	5.88	329.03	336.64	332.83	440.55	452.23	446.39	529.48	537.64	533.56
Integrated (75% organic + 25% inorganic)	5.79	5.86	5.82	302.04	306.73	304.38	420.73	424.91	422.82	502.79	508.73	505.76
Inorganic (100% RDF)	5.84	5.90	5.87	325.53	331.98	328.76	439.03	450.02	444.53	528.50	535.15	531.82
S.Em.±	0.11	0.10	0.08	6.56	6.64	4.67	6.22	8.56	5.29	8.80	9.03	6.30
C.D. (P=0.05)	NS	NS	NS	19.14	19.39	13.27	18.16	24.99	15.05	25.68	26.36	17.93

Table 3: Effect of chickpea varieties and integrated nitrogen management practices on crop growth rate at successive crop duration of chickpea

Treatments	Crop growth rate (g m^{-2} day^{-1})					
	Between 30-60 DAS			Between 60-90 DAS		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties						
GNG 2144	10.79	11.05	10.92	4.00	4.02	4.01
GNG 1581	10.96	11.26	11.11	3.89	3.83	3.86
GNG 2171	9.79	9.96	9.87	3.88	3.94	3.91
JG 16	8.77	8.81	8.79	3.79	3.92	3.86
S.Em.±	0.24	0.23	0.17	0.51	0.41	0.33
C.D. (P=0.05)	0.85	0.78	0.51	NS	NS	NS
Integrated nitrogen management						
Organic (100%)	9.01	9.15	9.08	4.11	3.98	4.05
Integrated (50% organic + 50% inorganic)	10.77	11.02	10.90	3.72	3.85	3.79
Integrated (75% organic + 25% inorganic)	9.87	10.03	9.95	3.96	3.94	3.95
Inorganic (100% RDF)	10.66	10.87	10.76	3.78	3.93	3.86
S.Em.±	0.22	0.22	0.16	0.36	0.41	0.27
C.D. (P=0.05)	0.64	0.65	0.44	NS	NS	NS

Table 4: Effect of chickpea varieties and integrated nitrogen management practices on relative growth rate at successive crop duration of chickpea

Treatments	Relative growth rate (g g^{-1} day^{-1})					
	Between 30-60 DAS			Between 60-90 DAS		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties						
GNG 2144	0.0583	0.0586	0.0584	0.0046	0.0044	0.0045
GNG 1581	0.0584	0.0586	0.0585	0.0044	0.0042	0.0043
GNG 2171	0.0572	0.0572	0.0572	0.0048	0.0048	0.0048
JG 16	0.0556	0.0555	0.0556	0.0051	0.0053	0.0052
S.Em.±	0.0005	0.0004	0.0003	0.0006	0.0004	0.0004
C.D. (P=0.05)	0.0019	0.0014	0.0010	NS	NS	NS
Integrated nitrogen management						
Organic (100%)	0.0559	0.0560	0.0560	0.0054	0.0052	0.0053
Integrated (50% organic + 50% inorganic)	0.0583	0.0585	0.0584	0.0042	0.0043	0.0043
Integrated (75% organic + 25% inorganic)	0.0572	0.0572	0.0572	0.0049	0.0047	0.0048
Inorganic (100% RDF)	0.0582	0.0583	0.0582	0.0043	0.0044	0.0044
S.Em.±	0.0005	0.0004	0.0003	0.0004	0.0005	0.0003
C.D. (P=0.05)	0.0014	0.0012	0.0009	NS	NS	NS

Table 5: Effect of chickpea varieties and integrated nitrogen management practices on number of nodules $plant^{-1}$ at successive growth stages

Treatments	Nodules $plant^{-1}$								
	30 DAS			60 DAS			90 DAS		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties									
GNG 2144	4.09	4.18	4.13	36.77	37.90	37.34	27.48	27.87	27.67
GNG 1581	4.12	4.19	4.16	37.21	38.13	37.67	27.92	28.10	28.01
GNG 2171	4.08	4.16	4.12	34.05	35.06	34.55	25.26	25.52	25.39
JG 16	4.04	4.14	4.09	31.39	32.33	31.86	23.05	23.17	23.11
S.Em.±	0.10	0.12	0.08	0.76	0.78	0.55	0.63	0.67	0.46
C.D. (P=0.05)	NS	NS	NS	2.64	2.71	1.69	2.19	2.32	1.42
Integrated nitrogen management									
Organic (100%)	4.03	4.12	4.07	32.48	33.23	32.86	23.61	23.90	23.75
Integrated (50% organic + 50% inorganic)	4.14	4.21	4.18	36.45	37.64	37.04	27.52	27.71	27.61
Integrated (75% organic + 25% inorganic)	4.07	4.16	4.11	34.33	35.24	34.78	25.39	25.63	25.51
Inorganic (100% RDF)	4.09	4.18	4.14	36.17	37.31	36.74	27.19	27.43	27.31
S.Em.±	0.10	0.09	0.07	0.62	0.68	0.46	0.60	0.58	0.42
C.D. (P=0.05)	NS	NS	NS	1.81	1.97	1.31	1.74	1.70	1.19

Table 6: Effect of chickpea varieties and integrated nitrogen management practices on number of branches plant^{-1} at successive growth stages

Treatments	Branches plant^{-1}								
	60 DAS			90 DAS			At harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties									
GNG 2144	8.19	8.37	8.28	10.69	10.72	10.71	10.65	10.70	10.67
GNG 1581	8.46	8.53	8.49	10.76	10.80	10.78	10.74	10.78	10.76
GNG 2171	7.51	7.83	7.67	9.74	9.96	9.85	9.70	9.92	9.81
JG 16	6.82	7.30	7.06	8.75	9.22	8.98	8.73	9.17	8.95
S.Em.±	0.19	0.15	0.12	0.24	0.21	0.16	0.27	0.21	0.17
C.D. (P=0.05)	0.67	0.52	0.38	0.84	0.72	0.49	0.94	0.74	0.53
Integrated nitrogen management									
Organic (100%)	6.99	7.23	7.11	9.04	9.21	9.13	9.03	9.20	9.11
Integrated (50% organic + 50% inorganic)	8.28	8.51	8.39	10.64	10.87	10.76	10.59	10.80	10.70
Integrated (75% organic + 25% inorganic)	7.59	7.86	7.72	9.74	9.96	9.85	9.72	9.94	9.83
Inorganic (100% RDF)	8.13	8.42	8.27	10.51	10.65	10.58	10.48	10.63	10.56
S.Em.±	0.16	0.14	0.11	0.21	0.20	0.15	0.18	0.21	0.14
C.D. (P=0.05)	0.47	0.41	0.30	0.61	0.60	0.42	0.54	0.60	0.39

Table 7: Effect of chickpea varieties and integrated nitrogen management practices on SPAD chlorophyll meter reading at successive growth stages

Treatments	SPAD chlorophyll meter reading					
	60 DAS			90 DAS		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Varieties						
GNG 2144	42.71	43.35	43.03	41.58	42.26	41.92
GNG 1581	42.81	43.52	43.17	41.91	42.66	42.29
GNG 2171	40.14	40.77	40.45	39.20	39.57	39.38
JG 16	37.59	38.27	37.93	36.79	36.99	36.89
S.Em.±	0.72	0.70	0.50	0.68	0.69	0.48
C.D. (P=0.05)	2.48	2.44	1.55	2.34	2.38	1.49
Integrated nitrogen management						
Organic (100%)	38.14	38.91	38.53	37.35	37.89	37.62
Integrated (50% organic + 50% inorganic)	42.66	43.10	42.88	41.51	42.04	41.77
Integrated (75% organic + 25% inorganic)	40.13	40.92	40.53	39.32	39.79	39.56
Inorganic (100% RDF)	42.31	42.98	42.64	41.31	41.75	41.53
S.Em.±	0.67	0.68	0.48	0.66	0.64	0.46
C.D. (P=0.05)	1.95	1.99	1.36	1.94	1.86	1.31

Conclusion

It can be concluded that the chickpea variety GNG 1581 recorded significantly higher growth as compared to rest of chickpea varieties. Amongst integrated nitrogen management practices, application of 50% N through organic manure + 50% N through chemical fertilizer at par with the application of 100% RDF through chemical fertilizer and both recorded significantly higher as compared to application of 75% N through organic manure + 250/0 N through chemical fertilizer and 100% N through organic manure.

Future research should focus on the long-term impacts of these integrated management practices on growth parameters, further contributing to sustainable agricultural systems.

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