



Impact of *in situ* Moisture Conservation Practices and Nitrogen Levels on Growth Analysis and Productivity of Pigeonpea (*Cajanus cajan* L.) under Rainfed Alfisols

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ABSTRACT

Background: To investigate the impact of *in-situ* moisture conservation practices and nitrogen fertilization practices on growth analysis and productivity of pigeonpea, a field investigation was carried out at Gunegal Research Farm, Central Research Institute for Dryland Agriculture, Hyderabad, during *kharif* 2022-23 and 2023-24.

Methods: During *kharif* seasons of 2022-23 and 2023-24, field experiments were carried out for two consecutive years at ICAR-Central Research Institute for Dryland Agriculture to evaluate the impact of *in-situ* moisture conservation practices and different levels of nitrogen on growth and productivity of pigeonpea under rainfed Alfisols of semi-arid tropics. The study was conducted in split-plot design with four different *in situ* moisture conservation practices as in main plots and four nitrogen levels as in subplots.

Result: The pooled data of the study showed that *in-situ* moisture conservation practices recorded higher yield due to improve growth and physiological indices of the crop because of better moisture availability to the plant. The increase in nitrogen application increased in yield. This increase in yield with nitrogen levels is attributed to higher nitrogen availability which helped in improvement in growth, physiological growth and crop productivity.

Key words: Growth indices, *In situ* moisture conservation practices, Nitrogen management, Pigeonpea.

INTRODUCTION

Pulses are important food crops in different countries as they are cheaper source of proteins, vitamins, dietary fibre and minerals etc. (Tewari *et al.*, 2019) and contribute to approximately 9 to 10% of total food grain production hence they play crucial role in food security, provide nutritional support and also helps in reducing environmental risks. Traditionally, more than 80% area under pulse production is under rainfed regions with poor soil fertility resulting in low productivity and high instability in production of pulses (Ahlawat *et al.*, 2016). Moreover, pulses increase the soil fertility status with their ability of atmospheric nitrogen fixation and improve physical structure and contributing to sustainable production systems and ultimately increasing the economy of the rainfed areas. Additionally, pulses fit well into mixed and intercropping systems and crop rotation (Sharma *et al.*, 2019).

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is the second important pulse crop after chickpea in India. Globally, India ranks first in the pigeonpea area (4.80 m ha) with a production of 4.28 m t and productivity of 892 kg ha⁻¹ (Directorate of Economics and Statistics, 2021). Though pigeonpea is a drought-tolerance crop with a deep-rooted system, prolonged dry spells occurred during early vegetative growth, flowering and pod formation stages severely affect crop growth and productivity (Sangma, 2020). In recent years, erratic distribution of rainfall, early onset and withdrawal of monsoon have made crop production more unstable in rainfed regions due to uncertainties in

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rainwater availability. The rainfed soils are not only thirsty, but they are also hungry. In general, rainfed soils are deficient in nutrients, particularly in nitrogen.

Moisture stress further aggravates the nitrogen deficiency. Nitrogen is essential for the plant growth as it is an integral part of the amino acids, protein, enzymes and chlorophyll molecule. The availability of nitrogen promotes development of the above-ground dark green tissues with soft consistency and contributes in increasing the grain yield. Hence, to achieve higher yields, it is crucial to regulate nitrogen fertilization. The nutrient and moisture stress reduces the input use efficiency of water and fertilizers, ultimately increases the cost of cultivation (Kumar *et al.*, 2023). Under these circumstances, to improve the productivity and sustainability of pigeonpea, it is essential to exercise control over these aspects. In this context, a study on moisture conservation and nitrogen management plays a vital role in enhancing the efficacy of its utilization. Efficient rainwater management practices through land configuration for *in-situ* rainwater conservation helps to conserve and enhance the moisture availability to the crop plants throughout the growth period of the crops (Garud *et al.*, 2019). Among various land configuration methods ridge and furrows, broad bed and furrows, tied ridges and furrows are effective in controlling surface runoff, soil erosion and increasing infiltration. Besides, moisture availability, these practices improve physico-chemical and biological properties of the soil (Ngangom *et al.*, 2020). Hence, the *in situ* moisture conservation practices and nitrogen level are the most critical for sustainable crop production and resource use efficiency under rainfed condition and provide insurance during abnormal rainfall situation.

Growth analysis is a conceptual framework for exploring the impact of management practices like moisture and nutrients on crop development. The study on crop growth and physiology such as leaf area, AGR, CGR and dry matter, prioritizes growth strategies in response to varying environmental challenges. It helps to enhance crop productivity and resilience in changing climate conditions. Growth indices are useful for interpreting plant responses to environmental stimuli.

On this backdrop there is need to study the impact of *in-situ* moisture conservation practices and nitrogen levels on growth and physiology of pigeonpea and to evolve an appropriate management practices of successful cultivation of pigeonpea that results in efficient rainwater conservation through land configuration and nitrogen levels for higher productivity of pigeonpea. Keeping the above fact in view the present investigation was conducted to study the impact of *in-situ* moisture conservation practices and nitrogen levels on growth analysis and productivity of pigeonpea.

MATERIALS AND METHODS

Experimental site

Field experiment was conducted during 2022-23 and 2023-24 for two consecutive years at Gunegal Research Farm (GRF), ICAR-Central Research Institute for Dryland Agriculture, Santhoshnagar, Hyderabad, India. The rainfall

received during crop growth period from July to December during 2022 and 2023 at experimental site was 799.5 mm in 46 rainy days and 440.7 mm in 25 rainy days respectively. The soil of the experimental field was sandy loam in texture and slightly acidic in reaction with pH of 6.4 and EC of 0.13 d Sm⁻¹. The N, P₂O₅ and K₂O and organic carbon content of soil was low (144.65 kg ha⁻¹), medium (28.54 kg ha⁻¹) and medium (236.53 kg ha⁻¹) and medium (0.64 %), respectively.

The experiment was laid out in split-plot design with *in-situ* moisture conservation practices *viz.*, flatbed sowing (I₁), flatbed with conservation furrow (CF) (I₂), raised bed with conservation furrow (CF) (I₃) and paired rows with conservation furrow (CF) (I₄) in main plot and nitrogen management practices *viz.*, Control (without fertilizer) (N₁), 75% RDN (N₂), 100 % RDN (N₃) and 125 % RDN (N₄) in sub-plots. The pigeonpea variety used for the investigation was 'WRGE-97'. The nitrogen was applied as per the treatments. The entire recommended dose of P₂O₅ and K₂O (60:60 kg ha⁻¹) for pigeonpea and nitrogen as per the treatments was applied as a basal dose. All the recommended agronomic practices were followed and appropriate weed, pest and disease management operations were followed.

The plant growth parameters (plant height, number of branches and dry matter accumulation) and physiological observations *viz.*, leaf area index (LAI) (Watson, 1958), Absolute growth rate (AGR) (West *et al.*, 1920), Crop growth rate (CGR), Relative growth rate (RGR) (Radford, 1967), Net assimilation rate (NAR) (Gregory *et al.*, 1926) and chlorophyll content with SPAD chlorophyll meter (Debtanu and Das, 2007) were recorded at vegetative, flowering, pod formation and harvest stages of pigeonpea as per the standard procedures. At maturity, the yield was recorded from the net plot area and computed to per hectare. Statistical analysis for all parameters was carried out in split-plot design with SAS software version 9.2 (English). ANOVA was computed and mean difference was made using least significant difference (LSD) at P≤0.05 level of significance.

RESULTS AND DISCUSSION

Growth parameters

The pooled analysis of the growth parameters revealed that *in situ* moisture conservation practices and nitrogen levels had significantly influenced the plant height, number of branches plant⁻¹ and dry matter production at all the growth stages of pigeonpea *viz.*, vegetative, flowering, pod formation and at harvest, while the interaction effect among themselves was found to be non-significant. The variation exerted by the *in-situ* moisture conservation practices and nitrogen levels on growth parameters *viz.*, plant height, number of branches plant⁻¹ and dry matter production at vegetative, flowering, pod formation and at harvest stage are given in Table 1a and 1b.

In situ moisture conservation practices recorded the highest growth like plant height, number of branches plant⁻¹

Table 1a: Influence of *in-situ* moisture conservation practices and nitrogen levels on plant height and number of branches plant⁻¹ at different growth stages of pigeonpea (Pooled data over two years).

Treatment	Plant height (cm)				No. of branches plant ⁻¹ at mid-flowering stage
	Vegetative	Flowering	Pod formation	At harvest	
<i>In situ</i> moisture conservation practices (I)					
I ₁ : Flatbed	35.6	107	138	144	11.0
I ₂ : Flatbed with CF	46.4	133	174	188	15.6
I ₃ : Raised bed with CF	45.6	131	171	185	15.1
I ₄ : Paired row with CF	43.6	128	166	180	14.7
SEm ±	0.99	2.3	2.6	3.9	0.29
CD (<i>P</i> = 0.05)	3.4	8	9	13	1.0
Nitrogen levels (N)					
N ₁ : Control	35.8	107	140	153	12.1
N ₂ : 75 % RDN	40.8	118	156	166	13.5
N ₃ : 100 % RDN	45.2	131	169	183	14.8
N ₄ : 125 % RDN	49.3	143	183	195	16.0
SEm ±	0.63	2.2	2.4	2.4	0.3
CD (<i>P</i> = 0.05)	1.8	6	7	7	0.83
Interaction					
<i>In-situ</i> moisture conservation with nitrogen levels (I at N)					
SEm ±	1.25	4.4	4.8	4.9	0.57
CD (<i>P</i> = 0.05)	NS	NS	NS	NS	NS
Nitrogen levels with <i>in situ</i> moisture conservation practices (N at I)					
SEm ±	1.47	4.5	4.9	5.7	0.57
CD (<i>P</i> = 0.05)	NS	NS	NS	NS	NS

Table 1b: Influence of *in-situ* moisture conservation practices and nitrogen levels on dry matter production and SPAD chlorophyll values at different growth stages of pigeonpea (Pooled data over two years).

Treatments	Dry matter production (kg ha ⁻¹)				SPAD values			
	Vegetative	Flowering	Pod formation	At harvest	Vegetative	Flowering	Pod formation	At harvest
<i>In situ</i> moisture conservation practices (I)								
I ₁ : Flatbed	137	1884	2982	3350	45.0	48.9	45.4	37.3
I ₂ : Flatbed with CF	213	2582	4481	4879	48.8	53.2	51.9	41.6
I ₃ : Raised bed with CF	205	2488	4329	4665	47.0	51.8	48.3	40.0
I ₄ : Paired row with CF	201	2437	4139	4567	46.5	51.6	46.5	38.4
SEm±	3.6	50.8	110.9	163.5	0.89	1.12	1.44	1.55
CD (<i>P</i> = 0.05)	13	176	384	566	NS	NS	NS	NS
Nitrogen levels (N)								
N ₁ : Control	1906	2959	3224	1906	45.4	49.8	45.6	37.4
N ₂ : 75 % RDN	2211	3567	3889	2211	46.5	51.3	47.1	38.6
N ₃ : 100 % RDN	2496	4418	4844	2496	47.2	51.6	48.8	39.8
N ₄ : 125 % RDN	2778	4986	5504	2778	48.2	52.7	50.5	41.5
SEm±	54.3	78.6	130.8	54.3	1.15	0.71	1.28	1.09
CD (<i>P</i> = 0.05)	159	229	382	159	NS	NS	NS	NS
Interaction								
<i>In situ</i> moisture conservation with nitrogen levels (I at N)								
SEm±	6.7	108.7	157.2	261.6	2.29	1.42	2.55	2.17
CD (<i>P</i> = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels with <i>in-situ</i> moisture conservation practices (N at I)								
SEm±	6.8	107.0	175.6	279.4	2.09	1.65	2.64	2.44
CD (<i>P</i> = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

and dry matter production at all the growth stages. Among the *in situ* moisture conservation practices, flatbed with CF (conservation furrow), raised bed with CF and paired row with CF recorded highest growth parameters. This higher growth might be due to better moisture availability for a longer period because of rainwater stored in conservation furrows. The better moisture availability helped the crop to escape from the stress during dry spells which in turn resulted in higher growth parameters (Kirar *et al.*, 2020; Vijayaprabhakar and Jayanthi, 2018). However, lowest growth was observed in flatbed sowing might be due to low stored soil moisture and poor moisture availability to the crops. Besides, low moisture restricted root growth because of low soil moisture and compacted soil under flatbed has resulted in poor growth (Sharma *et al.*, 2019).

Application of nitrogen increased growth parameters viz., plant height, number of branches plant⁻¹ and dry matter production throughout the crop growth stages. Application of 125% RDN recorded maximum growth parameters viz., plant height, number of branches plant⁻¹ and dry matter accumulation. This might be due to the higher nitrogen availability in soil which led to increase absorption of nutrients by pigeonpea which resulted in cell multiplication and elongation that might have helped in improved growth of pigeonpea (Dayanandanaik *et al.*, 2024; Kulkarni *et al.*, 2020 and Panchavati *et al.*, 2020). Control, i.e. no nitrogen application recorded the lower growth parameters of pigeonpea throughout the crop growth period. This might be attributed to poor growth of crops due to insufficient supply of nitrogen in the control treatment.

SPAD chlorophyll values

The pooled analysis of SPAD chlorophyll content gradually increased up to flowering stage of pigeonpea and later decreased with time due to senescence. *In situ* moisture conservation practices and nitrogen management did not significantly influenced the SPAD values in pigeonpea are presented in Table 1b. Highest values were recorded in flatbed with CF and raised bed

with CF compared to flatbed sowing method owing to increase availability of soil moisture and balanced supply of nutrients to the crop at all stages (Honnali and Biradar (2020). Application of 125% RDN recorded numerically higher SPAD values followed by 100% RDN. These results are in close association with findings Honnali *et al.* (2020) and Nagaraj *et al.* (2019).

Physiological growth

The physiological indices viz., leaf area index (LAI), absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) increased up to flowering stage and decreased thereafter. AGR is typically measured as an increment in total dry weight per plant over a specific unit of time, whereas, RGR expresses growth in terms of a rate of increase in weight per unit weight. NAR values were higher during early vegetative growth stages but declines as crop advance in age might be due to leaf mutual shading and decreased photosynthetic efficiency in older foliage (Amanullah *et al.*, 2010).

The physiological growth like LAI, AGR and CGR of pigeonpea were significantly influenced by *in-situ* moisture conservation practices and nitrogen levels during vegetative, flowering and pod formation stage of Pigeonpea. Whereas, RGR and NAR were significantly influenced by *in-situ* moisture conservation practices and nitrogen levels during vegetative stage only, Whereas, at later stages these parameters were non-significant during later stages of pigeonpea. The interaction effect among moisture conservation practices and nitrogen levels on all the physiological growth indices was not significant. The graphical representation of all the physiological indices viz., LAI, AGR, CGR, RGR and NAR as influenced by *in-situ* moisture conservation practices and nitrogen levels are presented in the Fig 1, 2a, 2b, 3a, 3b, 4a, 4b, 5a and 5b respectively.

Among the *in situ* moisture conservation practices, flatbed with CF recorded significantly higher LAI, AGR, CGR, RGR and NAR and this was on par with raised bed with CF

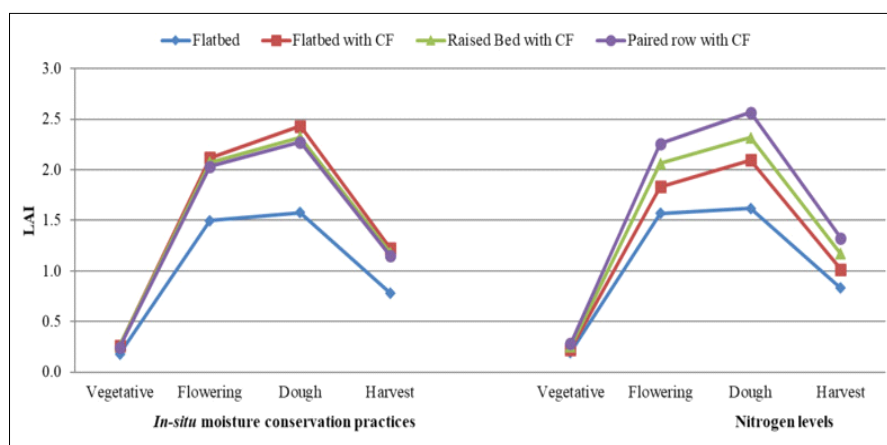


Fig 1: Influence of *in-situ* moisture conservation practices and nitrogen levels on leaf area index at different growth stages of pigeonpea (Pooled data of 2022-23 and 2023-24).

at all growth stages of pigeonpea except at harvest. Higher physiological indices in moisture conservation practices might be due to the availability of conserved rainwater in the furrows for a longer period. The higher moisture content

improved the crop growth of pigeonpea as compared to no moisture conservation practices. While, the lowest physiological indices were recorded in flatbed sowing *i.e.*, without moisture conservation practice at all growth stages

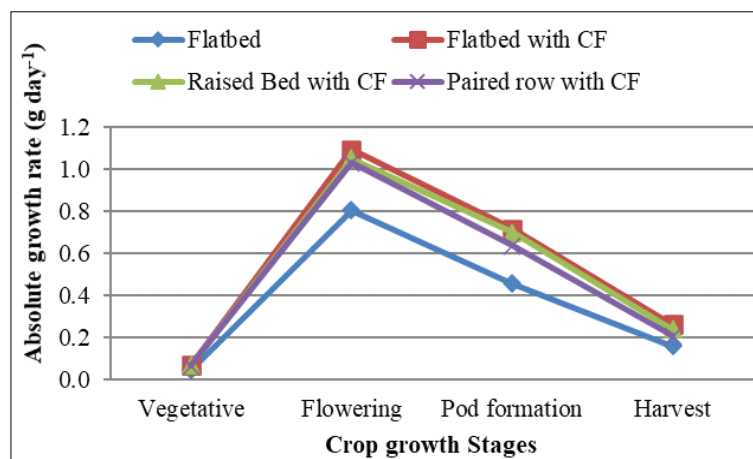


Fig 2a: Absolute growth rate of pigeonpea as influenced by *in situ* moisture conservation practices.

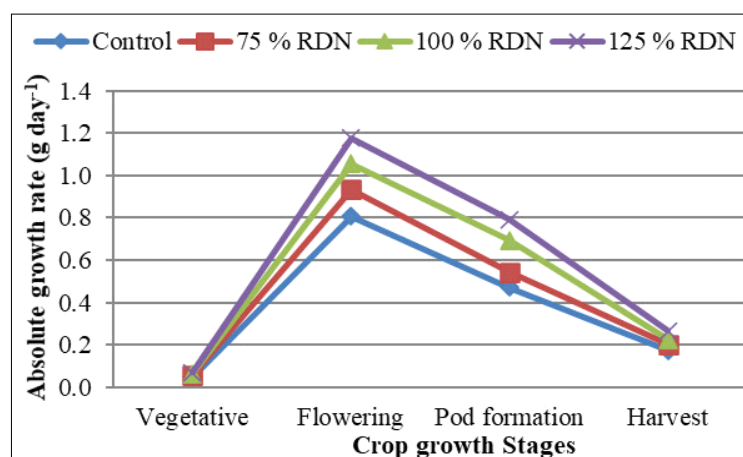


Fig 2b: Absolute growth rate of pigeonpea as influenced by nitrogen levels.

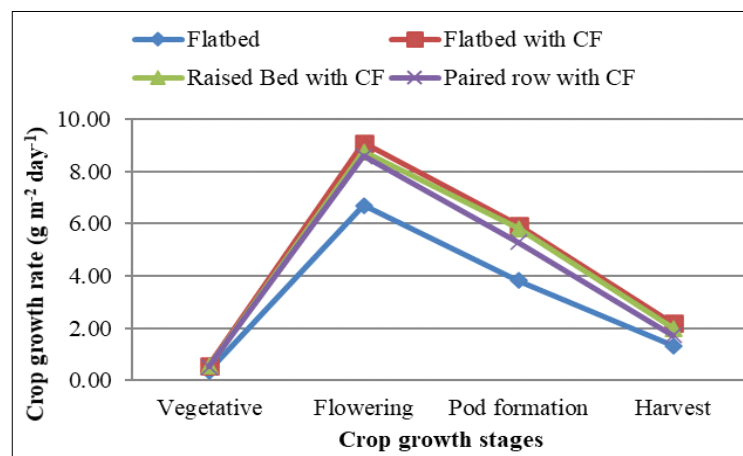


Fig 3a: Crop growth rate of pigeonpea as influenced by *in situ* moisture conservation practices.

of pigeonpea. This might be due to lower dry matter production resulted in lower physiological indices.

Nitrogen fertilization management exerted significant influence on LAI, AGR, CGR, RGR and NAR of pigeonpea.

Application of 125% RDN recorded significantly higher physiological indices of pigeonpea which was followed by 100% RDN and 75% RDN application during both the years as well as in pooled data. Higher dose of nitrogen

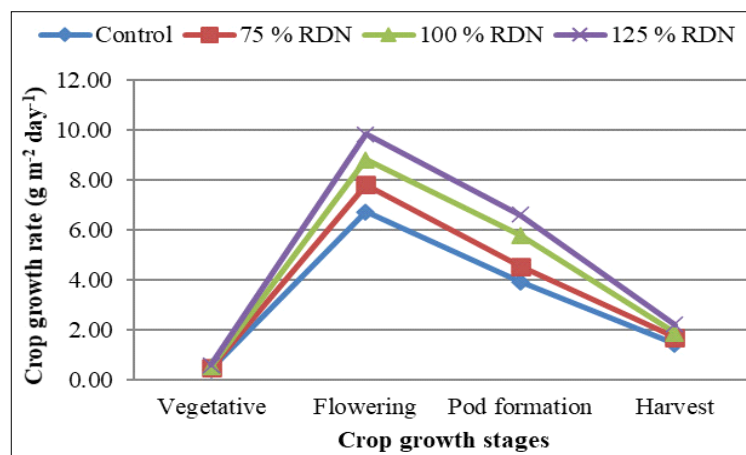


Fig 3b: Crop growth rate of pigeonpea as influenced by nitrogen levels.

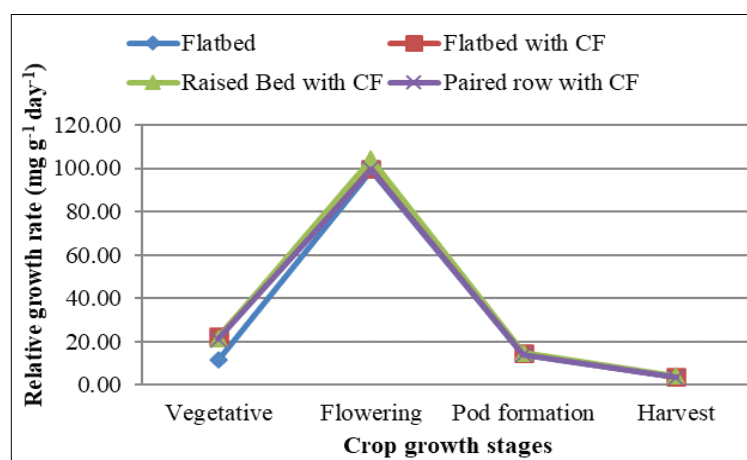


Fig 4a: Relative growth rate of pigeonpea as influenced by *in-situ* moisture conservation practices.

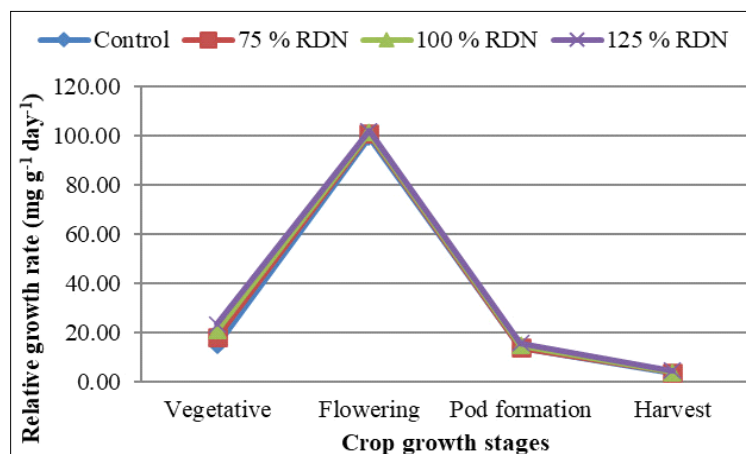


Fig 4b: Relative growth rate of pigeonpea as influenced by nitrogen levels.

application resulted in higher nitrogen availability and uptake by crop which reflected in the form of higher dry matter production ultimately leading to higher physiological indices. Significantly lower values of all the physiological indices were registered in control treatment during all stages of pigeonpea. The lower physiological growth in control could be attributed to the deficiency of nitrogen, leading to low dry matter production, indicating reduced photosynthetic activity. Consequently, this could have resulted in the lowest LAI, AGR, CGR, RGR and NAR. Higher doses of nitrogen improved the growth attributing characters viz., plant height, leaf area and dry matter production which might have increased the physiological growth. These results were in accordance with the findings of Dayanandanaik *et al.* (2024); Venkatalakshmi (2016).

Seed and stalk yield

The perusal of the pooled data of two years of seed and stalk yield presented in Table 2. revealed that flatbed with CF (conservation furrow) recorded higher seed and stalk

yield and was on par with raised bed with CF and paired row with CF in the individual years as well as in pooled mean. The conserved moisture in furrows supported crop growth at critical growth stages might have favored overall growth of crop and greater translocation of food material to the reproductive part which might have helped in higher seed and stalk yield. These results were in line with Raviraja *et al.* (2023); Shrivastava *et al.* (2018) and Sadavadiya *et al.* (2017). Flatbed sowing recorded significantly lower pooled seed yield as compared to other moisture conservation practices i.e., flatbed with CF, raised bed with CF and paired row with CF during both the years of study and in pooled mean.

Among the nitrogen levels 125% RDN application recorded highest seed and stalk yield in pooled mean and followed by 100% RDN and 75% RDN respectively. The crop yield increased with increase in nitrogen application. The increase in yield might be due to higher nitrogen availability which improved leaf area, this increase in leaf area has increased the SPAD chlorophyll content and

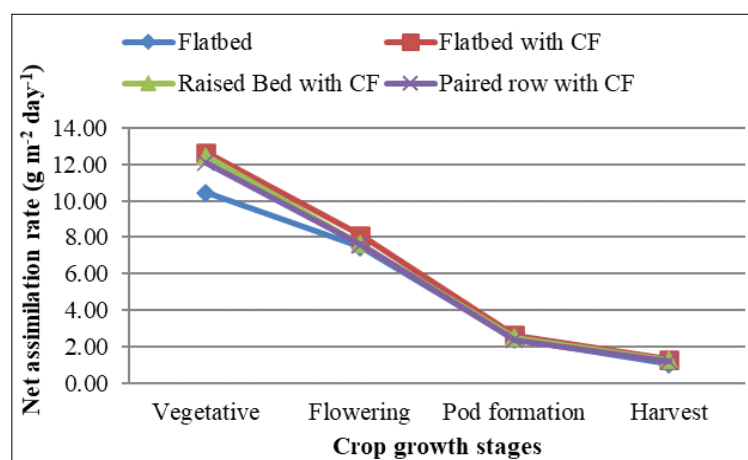


Fig 5a: Net assimilation rate of pigeonpea as influenced by *in-situ* moisture conservation practices.

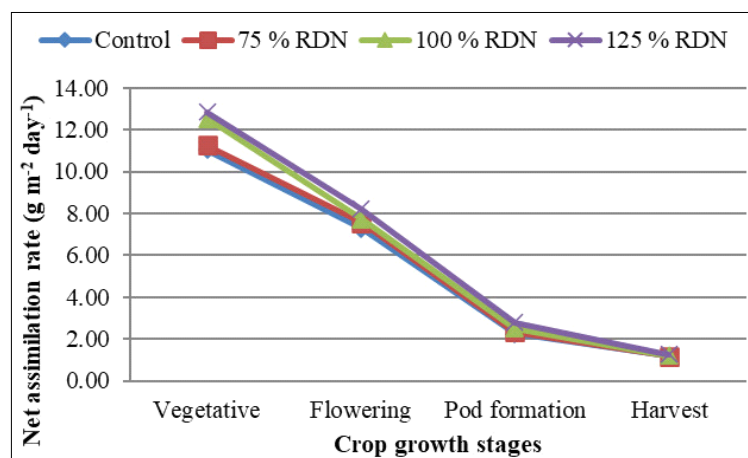


Fig 5b: Net assimilation rate of pigeonpea as influenced by nitrogen levels.

Table 2: Influence of *in situ* moisture conservation practices and nitrogen levels on seed and stalk yield of pigeonpea (Pooled data of 2022-23 and 2023-24).

Treatments	Seed yield (kg ha ⁻¹)	Stalk yield (kg ha ⁻¹)
<i>In situ</i> moisture conservation practices (I)		
I ₁ : Flatbed	839	2555
I ₂ : Flatbed with CF	1110	3319
I ₃ : Raised bed with CF	1057	3200
I ₄ : Paired row with CF	1040	3111
SEm±	27.1	65.4
CD (<i>P</i> = 0.05)	94	226
Nitrogen levels (N)		
N ₁ : Control	677	2359
N ₂ : 75% RDN	970	2910
N ₃ : 100% RDN	1138	3306
N ₄ : 125% RDN	1262	3611
SEm±	29.7	61.2
CD (<i>P</i> = 0.05)	87	179
Interaction		
<i>In situ</i> moisture conservation with nitrogen levels (I at N)		
SEm±	59.4	122.5
CD (<i>P</i> = 0.05)	NS	NS
Nitrogen levels with <i>in situ</i> moisture conservation practices (N at I)		
SEm±	58.1	124.6
CD (<i>P</i> = 0.05)	NS	NS

ultimately photosynthesis which might led to more dry matter production and consequently higher seed yield. These findings are in agreement with the findings of Honnali *et al.* (2020); Daka *et al.* (2020) and Panchavati *et al.* (2020). Significantly lowest seed and stalk yield of pigeonpea was recorded in control might be due to lowest crop growth and dry matter production led to reduction in seed and stalk yields. The interaction effect between *in-situ* moisture conservation practices and nitrogen levels did exerted significant influence on seed and stalk yield of pigeonpea in mean data of two years.

CONCLUSION

From this study, it was concluded that *in-situ* moisture conservation practices due to different land configuration practices like flatbed with conservation furrow, raised bed with CF and paired row with CF in combination with higher dose of nitrogen *i.e.*, 125% RDN application resulted in better growth and development and suitable for achieving higher yield of pigeonpea in alfisols of Hyderabad, India.

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Conflict of interest

The author declares that there are no known competing financial interests or personal relationships that could have

appeared to influence the legume research reported in this paper.

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