Indian Journal of Ecology (2024) 51(6): 1242-1245
DOI: https://doi.org/10.55362/IJE/2024/4387

Manuscript Number: 4387
NAAS Rating: 5.38

Water productivity and Quality of Chickpea as Influenced by Sowing Methods and Irrigation Regimes in Tarai Region of Uttarakhand

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***Abstract*:** Chickpea (*Cicer arietinum* L.) is an essential *rabi* pulse crop in India, yet its productivity suffers from irregular rainfall. Effective irrigation management is crucial to mitigate water stress and improve crop quality, thereby enhancing food and nutritional security amid growing resource competition. This study aimed to assess the impacts of different sowing methods and irrigation regimes on the water productivity and quality of chickpea at G. B. Pant University of Agriculture and Technology during the 2017-18 season. The experiment included two sowing methods (flat bed and raised bed), two irrigation methods (check basin and sprinkler), and three irrigation stages (vegetative, pod development, and both). The raised bed sowing and sprinkler irrigation improved total and biophysical water productivity. Specifically, sprinkler irrigation achieved an increase of 51.1, 25.0, and 15.3% in total and biophysical water productivity and protein yield, respectively. Single irrigation at the vegetative stage yielded the highest total and biophysical water productivity, while protein yield was significantly greater with two irrigations.

Keywords: Chickpea, Water productivity, Sprinkler, Raised bed

In India, chickpea (*Cicer arietinum* L.) is the most important *rabi* pulse crop, grown on over 9.59 million hectares with productivity of 1151 kilograms per hectare (Department of Agriculture and Farmers Welfare 2024). Chickpea, grown as a rainfed crop, is adversely affected by irregular rainfall patterns, impacting productivity. Insufficient moisture negatively affects germination, flowering, pod development, nitrogen fixation and in-turn yield (Rani et al 2020). Chickpea can undergo forced maturity under terminal drought. Excess moisture during the vegetative stage can negatively impact emergence and growth (Zaman et al 2024), increasing disease susceptibility (Dron et al 2021), while during the reproductive stage, it can harm flowers and pods, resulting in reduced yields. Thus, both extremes of soil moisture-too much or too little-result in decreased growth, development, and yield of chickpeas. Implementing controlled irrigation is the most effective way to address the problems of inconsistent rainfall and water stress. However, this has to be done against significant challenges due to increasing competition for water resources, declining per capita water availability, and India's transition from being water-stressed to water-scarce (https://www.adriindia.org /adri/india_water_facts, Ray et al 2023). Therefore, optimizing water use is crucial to managing water stress and improving chickpea yields. Furthermore, rising concerns about malnutrition are threatening the nutritional security of the nation (Ministry of Health and Family Welfare 2022).

Modifying methods of sowing and irrigation regimes in chickpea cultivation, offers a promising approach to cope with the aforementioned challenges. The raised bed sowing method is highly effective for areas with flood irrigation. In this approach, water is applied to furrows, where it seeps laterally to the root zone, helping to control the moisture levels around the roots. Chickpea sown in 75 cm raised bed was found to 23.3% more water efficient than chickpea sown in flat bed method. This increased efficiency was attributed to the higher yield achieved with less water application in the raised bed systems compared to flat bed sowing (Kumar et al 2015). Controlled irrigation can also be achieved using sprinkler systems, which maintains an optimum depth of irrigation and hence, particularly beneficial for sensitive crops like pulses. The experiment was conducted to evaluate different sowing methods and irrigation regimes influence the water productivity and quality of chickpea.

MATERIAL AND METHODS

Experiment details: A field study was carried out at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during the *rabi* season of 2017-18. The experiment was executed in factorial randomized block design examining two method of sowing (flat and raised bed), two irrigation methods (check basin and sprinkler), and three irrigation stages (irrigation at vegetative stage, pod development stage, and both the stages). The soil was sandy

loam, neutral (pH 7.02) with high organic carbon content (0.85 %), low nitrogen levels (218.5 kg/ha), high phosphorus levels (24.2 kg/ha), and medium potassium levels (182.5 kg/ha). The soil field capacity (FC) was 18.5%, while the permanent wilting point (PWP) was 6.4%.The rainfall throughout the crop growing season was only 13.6 mm.

Agronomic practices: Chickpea variety Pant Gram-186 was sown with 30 cm row spacing with seed rate 80 kg/ha. Raised beds were manually prepared with 90 cm spacing between center of two furrows, accommodating three rows per bed. Thinning was done at 15 days after sowing to maintain a plant distance of 8 ± 2 cm. Fertilizer was applied at 200 kg/ha using NPK 12:32:16, with irrigation depths 5 cm for flat beds and 3.5 cm for raised beds under check basin irrigation and 3 cm for sprinklers. The irrigations were given as per treatments. Other agronomic practices were executed as per standard recommendations.

Observations

Moisture extraction percentage: It was computed using following equation:

$$\text{Moisture extraction (\%)} = \frac{\text{Consumptive use of ith layer (cm)}}{\text{Total consumptive use (cm)}} \times 100$$

Consumptive use: The consumptive use (CU) was calculated using the formula:

$$\text{CU (cm)} = \sum_{i=1}^{n} \frac{(MAi - MBi) \times BDi \times Di}{100} + ER + PMC + (Evap. \times 0.85)$$

Where, MAi = % moisture on oven dry basis after irrigation in ith layer; MBi = % moisture on oven dry basis before irrigation in ith layer; BD = Bulk density of ith layer; Di = Depth of ith layer; n= number of layer; ER = Effective rainfall; PMC = Profile moisture contribution (Moisture at harvest – Moisture at sowing); Evap. = Evaporation; 0.85 = Correction factor

Total water productivity:

$$\text{TWP (kg/ha-cm)} = \frac{\text{Grain yield (kg/ha)}}{\text{Total water applied (cm)}}$$

Biophysical water productivity (Perry et al 2017):

$$\text{BWP (kg/ha-cm)} = \frac{\text{Grain yield (kg/ha)}}{\text{Consumptive use (cm)}}$$

Nitrogen and Protein content : The total nitrogen content was determined by modified Kjeldahl method. Thereafter protein content was determined by multiplying nitrogen content with 6.25.

Protein yield in grains : The protein yield was calculated using following formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Grain yield (kg/ha) x Protein content (\%)}}{100}$$

Statistical analysis: Analysis was carried out using R software and Fisher's least significant test was used to compare the mean values at 5% level of significance.

RESULTS AND DISCUSSION

Moisture extraction percentage: Moisture extraction percentage at depths of 0-15 cm, 15-30 cm, and 30-45 cm were 40.60, 33.39, and 26.01%, respectively, in flat beds, whereas in raised beds, they were 40.64, 31.5, and 27.86%. Moisture removal pattern from different layers was more uniform in raised beds indicating that roots were well distributed in the entire zone than flat sowing. In check basin irrigation, moisture extraction from soil depths of 0-15 cm, 15-30 cm, and 30-45 cm was 42.07, 31.93, and 26.00%, respectively. In comparison, sprinkler irrigation resulted in moisture extraction of 39.17, 32.95, and 27.87 from the same soil depths. The increased moisture extraction from deeper soil layers under sprinkler irrigation may be attributed to reduced moisture availability in the top layer and improved aeration, which encouraged roots to grow into deeper soil zones to meet crop water demands.

The average moisture extraction during two irrigations at the vegetative and pod development stages was 42.10, 31.84, and 26.06% from soil depths of 0-15, 15-30 and 30-45 cm, respectively. This pattern reflects the combined impact of the two irrigations, which increased moisture availability in the top layer. In contrast, single irrigation treatments resulted in lower moisture extraction from the top layer due to reduced moisture availability compared to treatments with two irrigations.

Water productivity: Raised bed systems exhibited greater total and biophysical water productivity, yielding 213.9 and 78.2 kg/ha-cm, respectively, compared to flat beds, which yielded 180 and 76.6 kg/ha-cm. This can be attributed to a slightly higher grain yield though non-significant in the raised bed, likely due to improved sunlight penetration and optimal moisture and aeration levels in the rhizosphere. The average moisture content 48 hours after irrigation was higher in the flat bed (15.82%) compared to the raised bed (13.86%). The

Table 1. Moisture extraction pattern (%) under different sowing, irrigation methods and stages

Treatment	0-15 cm	15-30 cm	30-45 cm
Sowing method			
Flat bed	40.6	33.39	26.01
Raised bed	40.64	31.5	27.86
Irrigation method			
Check basin	42.07	31.93	26.00
Sprinkler	39.17	32.95	27.87
Irrigation stage			
Vegetative	39.31	32.20	28.49
Pod development	40.46	33.28	26.26
Both	42.10	31.84	26.06

lower soil moisture in raised beds suggests that sensitive crops like chickpeas will thrive better in raised bed systems than in flat sowing but may be due to less rainfall, significant changes could not be found (Agrawal et al 2022). Sprinkler irrigation was associated with significantly higher grain yields and reduced water application, resulting in 51.1% higher total water productivity and 25.03% greater biophysical water productivity. Under sprinkler irrigation, the controlled and uniform water supply likely enhanced the crop's micro-climate, promoting efficient water and nutrient use. In terms of soil moisture, check-basin irrigation resulted in an average of 16.74% moisture 48 hours after irrigation, compared to 12.94% with the sprinkler method. Since chickpeas are highly sensitive to moisture stress, they may have suffered from excess moisture in the root zone with check-basin irrigation. Furthermore, this method may lead to soil particles settling more tightly, reducing airflow in the rhizosphere and potentially causing stunted growth in the plants (Agrawal et al 2022).Significantly higher water productivity was found in sprinkler irrigation over check basin irrigation based on two years study in chickpea in sandy loam soil of Morena (Madhya Pradesh) (Singh et al 2017).

Two irrigations at the vegetative and pod development stages led to the highest total water applied (8.61 cm) and consumptive use (17.80 cm), which corresponded to lower total and biophysical water productivity, respectively. Irrigations during the vegetative and pod development stages led to grain yields that were significantly higher by 17.15% and 22.10%, respectively, compared to a single irrigation at either stage. Providing two irrigations at these critical points ensured a better moisture supply, which helped prevent prolonged stress on the chickpea crop. Both growth and yield attributes were significantly enhanced, ultimately boosting overall yield (Agrawal et al 2022). Singh et al (2024) revealed that irrigation water productivity of two irrigations at branching and pod development stages is lowest as compared to single irrigation at either stages. Total and biophysical water productivity improved as the number of irrigations decreased. The single irrigation at the vegetative stage achieved the highest total and biophysical water productivity (232.5 and 82.4 kg/ha-cm, respectively) due to the lowest consumptive use (14.08 cm), lower total water applied (4.99 cm), and higher yield compared to a single irrigation at the pod development stage.

Quality parameters: Sowing methods and irrigation regimes did not have a significant effect on the nitrogen (N) content in the grain. There were no significant differences in the protein content of the grains across the treatments, consistent with the lack of significant variation in nitrogen content. The protein yield among the various sowing, did not differ significantly although a slightly higher protein yield was observed with the raised bed method compared to the flat bed method. Protein yield was significantly greater in the sprinkler irrigation system (272 kg/ha) compared to the check basin irrigation (236 kg/ha), which was attributed to the significantly higher grain yield in the former. Singh et al (2017) reported that significantly higher protein yield was in sprinkler irrigation over check basin. Protein yield was significantly higher with two irrigations at the vegetative and pod development stages (287 kg/ha) compared to a single irrigation at either the vegetative stage (242 kg/ha) or the pod development stage (234 kg/ha).

Table 2. Water productivity and quality parameters of chickpea as influenced by different sowing methods, irrigation methods and application stages

Treatment	Total water applied (Irrigation + Rainfall) (cm)	Consumptive use (cm)	Total water productivity (kg/ha-cm)	Biophysical water productivity (kg/ha-cm)	N content (%)	Protein content (%)	Protein yield (kg/ha)
Sowing method							
Flat bed	6.69	15.72	180.0	76.6	3.35 [a]	20.96[a]	252 [a]
Raised bed	5.69	15.56	213.9	78.2	3.37 [a]	21.05 [a]	257 [a]
Irrigation method							
Check basin	7.03	16.28	160.0	69.1	3.36 [a]	20.99 [a]	236[b]
Sprinkler	5.36	15.00	241.8	86.4	3.36 [a]	21.02 [a]	272[a]
Irrigation stage							
Vegetative	4.99	14.08	232.5	82.4	3.34 [a]	20.90 [a]	242 [b]
Pod development	4.99	15.05	223.0	74.0	3.36 [a]	20.98 [a]	234[b]
Both	8.61	17.80	157.8	76.3	3.38 [a]	21.14 [a]	287 [a]

Values followed by different lowercase letters (a-b) are significantly different at 5%

CONCLUSION

The raised bed and sprinkler irrigation are beneficial for water sensitive crops like chickpea. Moreover, two irrigations at vegetative and pod development stages are advantageous for obtaining higher protein yield of chickpea.

REFERENCES

Agrawal A, Chandra S and Singh G 2022. Performance of chickpea (*Cicer arietinum*) under different land configurations, irrigation methods and schedules in sandy-loam soil. *Indian Journal of Agronomy* **67**(2): 165-169.

Department of Agriculture and Farmers Welfare 2024. *Agricultural Statistics at a Glance 2023*. p42.

Dron N, Sutton T, Harden S, Simpfendorfer S and Hobsen K 2021. Phenotyping for waterlogging tolerance as a proxy for *Phytophthora medicaginis* resistance in chickpea. *Plant Health Progress* **22**(3): 287-293.

Kumar, N, Singh MK, Praharaj CS, Singh U and Singh SS 2015. Performance of chickpea under different planting method seed rate and irrigation level in Indo-Gangetic Plains of India. *Journal of Food Legumes* **28**(1): 40-44.

Ministry of Health & Family Welfare 2022. N*ational Family Health Survey NFHS-5 2019-21* Volume I.373p.

Received 14 September, 2024; Accepted 22 October, 2024

Perry C, Steduto P and Karajeh F 2017. *Does Improved Irrigation Technology Save Water? A Review of The Evidence. Agriculture Water Management.* Food and Agriculture Organization of the United States. Cairo, Egypt.

Rani A, Devi P, Jha UC, Sharma KD, Siddique KHM and Nayyar H 2020. Developing climate-resilient chickpea involving physiological and molecular approaches with a focus on temperature and drought stresses. *Frontiers in Plant Science* **10**(1759): 1-29.

Ray LIP, Swetha K, Singh AK and Singh NJ 2023. Water productivity of major pulses: A review. *Agricultural Water Management* **281**(108249): 1-11.

Singh G, Baurai R, Singh M and Bhattacharyya S 2024. Variable irrigation phasing and establishment techniques in chickpea (*Cicer arietinum* L.) under sprinkler and flood irrigation system in Tarai region of Uttarakhand. *Indian Journal of Ecology* **51**(2): 384-390.

Singh YP, Tomar SS, Singh AK and Yadav RP 2017. Effect of nutrition management and irrigation methods and schedule on productivity, economics and water- use efficiency in soybean (*Glycine max*) – chickpea (*Cicer arietinum*) cropping sequence in alluvial soil. *Indian Journal of Agronomy* **62**(4): 424-430.

Zaman MSU, Malik AI, Luna LN, Hossain MA, Alam AKMM, Prodhan MA and Erskine W 2024. Differences of waterlogging tolerance in winter pulse crop between emergence and vegetative stages. *Journal of Agronomy and Crop Science* **210**(2): e12704.