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Effect of Irrigation and Moisture Conservation Practices on nutrient content and uptake of chickpea (*Cicer arietinum* L.)

Mohit Kumar Sharma[1], S.K. Intodia[2], Arvind Verma[3], K.K Yadav[4], Devendra Jain[5*], Seema Kuldeep[6]

[1]M.Sc. Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India
[2]Professor, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India
, [3]Professor, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India
[4]Professor and Head, Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India
[5]Assistant Professor, Department of MBBT, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India
[6]M.Sc. Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India
Molecular Biology and Biotechnology, RCA, MPUAT, Udaipur, India

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***Abstract*— *In the rabi season of 2024-25, a field experiment entitled "Effect of Irrigation and Moisture Conservation Practices on nutrient content and uptake of chickpea (Cicer arietinum L.)" was conducted at the Agronomy Instructional Farm, Rajasthan College of Agriculture, Udaipur, Rajasthan. The experimental field comprised clay loam soil with medium fertility status. The experiment was laid out in a split-plot design, main plot treatments included four irrigation schedules: no irrigation (I_0), irrigation at pre-flowering (I_1), at pod formation (I_2) and at both pre-flowering and pod formation stages (I_3). The sub-plot treatments comprised four moisture conservation practices: control (M_0), hydrogel @ 2.5 kg ha^{-1} (M_1), dust mulch (M_2) and maize stover mulch (M_3) with three replications. The results revealed that irrigation at pre-flowering and pod formation stages (I_3) significantly enhanced nutrient content and uptake. The highest nitrogen, phosphorus and potassium contents in seed (3.65%, 0.36% and 0.78%, respectively) and haulm (1.40%, 0.25% and 1.59%, respectively) were recorded under I_3. Among moisture conservation practices, maize stover mulch (M_3) and hydrogel (M_1) significantly improved nutrient concentrations. Nutrient uptake by seed and haulm was also maximized under irrigation at pre-flowering and pod formation and maize stover mulch, with total nitrogen, phosphorus and potassium uptake reaching 132.59, 18.86 and 80.24 kg ha^{-1}, respectively. These results highlight the synergistic role of optimal irrigation and effective moisture conservation in improving nutrient dynamics in chickpea.*

***Keywords*— irrigation, Maize stover mulch, Hydrogel, Dust mulch**

I. INTRODUCTION

Chickpea popularly known as Gram, Chana, or Bengal-gram in India comprise 44 species including 35 perennials and 9 annuals. Based on its seed shape, chickpeas are classified into two market types: kabuli and desi. Chickpea offers a low-cost source of protein for vegetarian populations (Knights and Hobson, 2016). Its seeds are rich in minerals phosphorus 340 mg, calcium 190 mg, magnesium 140 mg, iron 7 mg and zinc 3 mg per 100 grams. One hundred grams of chickpea seeds provide about 360 calories. Chickpea is beneficial to health as they purify blood and reduce cholesterol by cleansing it. Gram is a *rabi* season crop that thrives in cold and dry conditions typical of semi-arid regions.

India is the world's largest producer and consumer of chickpea. The production per unit area has shown a gradual but consistent increase since 1961, with an average annual growth of approximately 6 kg ha^{-1}. According to the second advance estimates of the Department of Agriculture & Farmers Welfare (DA&FW) for the year 2024-25, chickpea production is estimated at 115.35 lakh metric tonnes (LMT), However, the all-India production has declined by 6.09 per cent compared to the average of the past three years. Maharashtra remains the leading contributor, accounting for 26.48 per cent of the total chickpea production in 2024-25. Rajasthan ranks third with an estimated production of 21.85 LMT after Maharashtra and Madhya Pradesh (DA&FW, 2024-25).

Among the various water-management practices, irrigation scheduling is one of the important managerial activities and affects the effective and efficient utilization of water by the crops. It determines the process to decide when to irrigate the crops and how much water to apply. It optimizes agricultural production by minimizing yield loss due to water shortage and improving the performance and sustainability of any irrigation system through conserving water. Irrigation application at critical stage is more important (Singh *et al.* 2016). In Rajasthan Chickpea cultivation faces water deficits due to dry conditions. Proper irrigation schedules can significantly improve yield levels and increase farmers' income. Water is a crucial input for all practices and efficient water utilization is essential. Proper irrigation management can increase yield by 100-150 per cent depending on soil type and time. However, systematic studies on different irrigation regimes for higher yields in short growing seasons are lacking (Khade *et al.,* 2016).

Moisture conservation practices like mulching, water absorbent (Hydrogel) etc. may decrease evaporation and conserve soil moisture and thereby increase yield of crops under water scarcity condition. Mulching is one such approach to increased yield of crops, raise crop successfully and economically. Straw mulching, a widely promoted cultivation technique in arid and semi-arid areas, reduces soil water evaporation, increases crop yield and improves water use efficiency. Straw mulch, derived from cereal crop stalks, safeguards soil from extreme temperatures, prevents weed growth and retains moisture. It preserves soil structure, reduces rain and wind impact, prevents soil erosion and enhances soil quality by reducing water evaporation and increasing moisture (Ma *et al*., 2024). Dust mulching controls weeds and some believe that it also conserves soil moisture by disrupting capillary action that would wick soil moisture to the surface. Dust mulching has been used as a floor management strategy for preserving soil moisture in dry-farmed production Dust mulching creates a fine soil layer on the surface to conserve soil moisture by disrupting evaporation channels (Davis *et al.,*2025)

Hydrogels are highly water-absorbent materials that can retain and gradually release water, improving soil moisture retention and enhancing agricultural productivity in water-scarce regions. Hydrogel application presents a sustainable and promising solution for improving soil-water retention and plant survival, especially in areas with high water scarcity and soil degradation (Amboka *et al.,* 2025)

II. MATERIALS AND METHODS

The experiment was conducted during *rabi* season of 2021-22 and 2022-23 at the Instructional Farm of Agronomy, Department of Agronomy, Rajasthan College of Agriculture, Udaipur which is situated at 24°35' N latitude, 73°42' E longitude with an altitude of 581.13 m above mean sea level. The region falls under NARP agro-climatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan, India. The soil of experimental site was clay loam in texture, having slight alkaline reaction (pH 8.2). The soil of the experimental field was medium in available nitrogen (261.23 kg ha^{-1}) and phosphorus (17.49 kg ha^{-1}) and high in available potassium (296.46 kg ha^{-1}) in both years of the experimentation. The chickpea variety GNG-2144 was sown as per treatments. As per recommendation, fertilizer application was made through urea and DAP.

Treatment details

Irrigation (I): irrigation treatment was comprise with control (No irrigation), pre-flowering, pod formation, pre-flowering and pod formation stages. No irrigation applied in control treatment.

Moisture conservation practices (M): Moisture conservation practices treatment incuding control, Hydrogel 2.5 kg ha^{-1}, dust mulch, Maize stover mulching. Hydrogel was applied at the time of sowing and dust mulch practice done tow times during crop season, maize stover mulch 5 t ha^{-1} was applied at 10 DAS.

III. RESULTS AND DISCUSSION

Nutrient Content

The data presented in Table 1 revealed that both irrigation and moisture conservation practices significantly influenced nitrogen, phosphorus and potassium content in chickpea seed and haulm. Among the irrigation levels, the maximum nitrogen content in seed (3.65%) was recorded under irrigation at both pre-flowering and pod formation stages (I_3), which was significantly higher than irrigation at pre-flowering (I_1), pod formation (I_2) and control (I_0), showing respective increases of 3.39, 3.69 and 8.30%. Similarly, nitrogen content in haulm was also maximized under irrigation at both pre-flowering and pod formation stages (1.40%), which was at par with pod formation stage (1.38%) and superior to pre-flowering (1.37%) and control (1.32%). In terms of moisture conservation, maize stover mulch (M_3) recorded the highest nitrogen content in both seed (3.58%) and haulm (1.39%) and was statistically at par with hydrogel (M_1). These treatments showed a clear advantage over dust mulch (M_2) and control (M_0), indicating that moisture retention led to enhanced nitrogen assimilation. Phosphorus content in seed was significantly influenced by moisture conservation, with the highest value (0.38%) found under maize stover mulch (M_3), closely followed by hydrogel (M_1) and dust mulch (M_2). Irrigation levels had a positive but statistically non-significant effect. In haulm, phosphorus content followed a similar trend with highest values under I_3 and M_3. The maximum potassium content in seed (0.78%) was observed under I_3, which was at par with I_2 (0.77%) and significantly superior to I_1 and control. Among mulch treatments, M_3 (0.78%) and M_1 (0.77%) showed a similar increase. In haulm, the maximum potassium content (1.59%) was recorded under I_3, with M_3 (1.58%) being the most effective moisture conservation practice. The increased nutrient concentration in seed and haulm under I_3 and M_3 may be attributed to better soil moisture availability, enhanced microbial activity and improved nutrient transport mechanisms. These findings are in agreement with Bhadoria (2018) and Rathva (2021), who reported improved nutrient assimilation under optimized irrigation and mulching regimes.

Table 4.9 Effect of irrigation and moisture conservation practices on nutrient content in chickpea

Treatments	Nutrient content (%)					
	Nitrogen		Phosphorus		Potassium	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Irrigation						
Control (I_0)	3.366	1.323	0.359	0.262	0.747	1.517
At Pre flowering (I_1)	3.531	1.373	0.370	0.267	0.762	1.546
At Pod formation (I_2)	3.517	1.385	0.370	0.268	0.775	1.578
At Pre flowering and Pod formation (I_3)	3.647	1.395	0.375	0.274	0.777	1.593
S.Em. ±	0.029	0.009	0.003	0.002	0.006	0.012
C.D. (P=0.05)	0.101	0.031	0.010	0.007	0.021	0.040
Moisture conservation practices						
Control (M_0)	3.415	1.346	0.364	0.261	0.748	1.540
Hydrogel (M_1)	3.576	1.384	0.367	0.268	0.769	1.563
Dust Mulch (M_2)	3.492	1.358	0.365	0.267	0.763	1.553
Maize Stover Mulch (M_3)	3.577	1.388	0.377	0.274	0.781	1.578
S.Em. ±	0.026	0.008	0.002	0.002	0.006	0.008
C.D. (P=0.05)	0.076	0.025	0.006	0.005	0.017	0.023

Nutrient Uptake

Irrigation and moisture conservation practices significantly influenced nitrogen uptake by seed and haulm (Table 2). Maximum nitrogen uptake by seed (76.62 kg ha^{-1}) and haulm (56.03 kg ha^{-1}) was recorded under I_3. This accounted for increases of 34.21% (seed) and 32.30% (haulm) over control. Moisture conservation with maize stover mulch also showed superior performance, recording seed and haulm uptake of 72.34 and 53.56 kg ha^{-1}, respectively. Total nitrogen uptake peaked under the I_3M_3 combination (140.53 kg ha^{-1}), indicating the additive effect of both practices. A similar trend was observed for phosphorus uptake. Seed phosphorus uptake was highest under I_3(7.87 kg ha^{-1}), while haulm uptake (10.99 kg ha^{-1}) also showed the same treatment as superior. Moisture conservation with maize stover mulch significantly enhanced both seed (7.62 kg ha^{-1}) and haulm (10.57 kg ha^{-1}) phosphorus uptake. Total phosphorus uptake was highest (18.86 kg ha^{-1}) under I_3, with M_3 being the most effective mulch treatment (18.19 kg ha^{-1}). Irrigation at pre-flowering and pod formation stages (I_3) led to the highest potassium uptake in both seed (16.31 kg ha^{-1}) and haulm (63.93 kg ha^{-1}), followed by I_2 and I_1. Maize stover mulch (M_3) similarly showed higher potassium uptake in seed (15.78 kg ha^{-1}) and haulm (60.84 kg ha^{-1}). Total potassium uptake was maximized under the I_3M_3 treatment combination. The observed improvement in nutrient uptake can be ascribed to increased dry matter production and improved nutrient content per unit biomass under higher soil moisture conditions. Better nutrient availability in the rhizosphere and enhanced root function under irrigated and mulched conditions contributed to greater nutrient assimilation and translocation. These results are supported by the work of Narayan (2019), Kumar and Angadi (2016) and Emamzada (2015). Irrigation at pre-flowering and pod formation stages (I_3) and maize stover mulch (M_3) significantly improved nutrient content and uptake in chickpea. These practices enhanced nitrogen, phosphorus and potassium levels in seed and haulm, leading to better nutrient assimilation and productivity. Their combined use is effective for improving nutrient efficiency under moisture-limited conditions.

Table 2. Effect of irrigation and moisture conservation practices on nutrient uptake by chickpea

Treatments	Nutrient uptake (%)								
	Nitrogen			Phosphorus			Potassium		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Irrigation									
Control (I_0)	57.05	42.35	99.40	6.09	8.39	14.48	12.66	48.54	61.20
At Pre flowering (I_1)	67.26	49.72	116.98	7.03	9.68	16.71	14.50	56.05	70.55
At Pod formation (I_2)	68.29	51.31	119.60	7.17	9.92	17.08	15.05	58.42	73.47
At Pre flowering and Pod formation (I_3)	76.57	56.03	132.59	7.87	10.99	18.86	16.31	63.93	80.24
S.Em. ±	1.66	1.34	0.98	0.17	0.31	0.21	0.35	1.55	1.32
C.D. (P=0.05)	5.76	4.63	3.40	0.58	1.07	0.73	1.22	5.35	4.56
Moisture conservation practices									
Control (M_0)	59.62	45.02	104.64	6.34	8.75	15.08	13.03	51.53	64.56
Hydrogel (M_1)	71.36	52.43	123.79	7.33	10.17	17.49	15.35	59.24	74.59
Dust Mulch (M_2)	65.84	48.38	114.22	6.87	9.49	16.36	14.36	55.33	69.69
Maize Stover Mulch (M_3)	72.34	53.57	125.90	7.62	10.57	18.19	15.78	60.84	76.62
S.Em. ±	1.318	1.00	1.34	0.13	0.22	0.21	0.30	1.10	1.06
C.D. (P=0.05)	3.84	2.93	3.90	0.37	0.65	0.63	0.88	3.21	3.09

IV. CONCLUSION

Irrigation at pre-flowering and pod formation stages (I_3) and maize stover mulch (M_3) significantly improved nutrient content and uptake in chickpea. These practices enhanced nitrogen, phosphorus, and potassium levels in seed and haulm, leading to better nutrient assimilation and productivity. Their combined use is effective for improving nutrient efficiency under moisture-limited conditions.

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