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Response of Chickpea to Irrigation and Nitrogen Levels in Loamy Sand Soil of North Gujarat

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***Abstract*:** A Field experiment was conducted at S.D. Agricultural University, Sardarkrushinagar, to study the response of chickpea to irrigation and nitrogen levels during *rabi* season of 2021-22 on loamy sand soil of North Gujarat. Grain and straw yield of chickpea increased significantly with at each higher level of irrigation scheduling up to 0.8 IW/CPE ratio with water application of 450 mm along with 100% RDN (20 kg/ha). Highest nitrogen content in seed and NPK uptake was recorded with 1.0 IW/CPE ratio which was at par with 0.8 IW/CPE ratio. Similarly, 125% RDN recorded at highest nitrogen content and NPK uptake which was at par with 100% RDN. Interaction effect between irrigation scheduling and nitrogen levels on seed yield and total nitrogen uptake by chickpea crop was highly significant. The highest field water use efficiency of chickpea with 0.6 IW/CPE ratio. Applied water with seed yield and field water use efficiency followed quadratic function with regression coefficient (R^2) of 0.99. Similarly, regression coefficient of applied water with NPK uptake (0.946, 0.973, 0.982) and applied nitrogen with NPK uptake (0.904, 0.974, 0.960) were highly significant and reflected close relationship between them.

***Keywords*:** Chickpea, Irrigation, Nitrogen levels, Nutrient uptake, WUE, Yield

Pulses are wonderful gifts of nature occupy a unique place in Indian agriculture by virtue of its high protein content and its capacity to enrich the soil fertility through the mechanism of symbiotic nitrogen fixation. Currently, the higher population growth and low protein content of cereals has attracted the attention of people to pulses consumption as most effective sources of protein for vegetarian population of India. Among the different pulses, chickpea (*Cicer arietinum* L.), is second important pulse crop in the world which is commonly known as Bengal gram belongs to genus *Cicer*, family *Leguminoceae* and sub family *Papilionaceae.* It is grown on a wide range of soils from medium to heavy black during *rabi* season with optimum temperature of 24-30°C. It is a rich and cheap source of protein it helps people to improve the nutritional quality of their diet. In India, chickpea cultivated over an area of 9.99 million hectare with a production of 11.91 million tones and productivity of 1092 kg/ha (Anonymous 2021a). In Gujarat area, production and productivity of chickpea was 1.10 million hectare, 2.10 million tones and 1908 kg/ha, respectively (DES 2021). The major constraint attributing to low production of chickpea is scare and untimely water supply, poor fertility status of soil and nutrient management. Therefore, it has to be used in the most efficient manner at proper time and quantity to realize the use efficiency. During the winter season, less water is required at early stage of crop while, at later crop growth stages water requirement increases due to rapid increase in evapotranspiration demand so that among different approaches for scheduling irrigation, climatological approach based on the ratio between depth of irrigation water (IW) and cumulative pan evaporation (CPE) is found the most appropriate, scientific and practicable, as it integrates all the weather parameters. It determines the process to decide when to irrigate the crop and how much water is to be applied. Optimum scheduling of irrigation led to increase in yield and WUE in case of chickpea.

Among the major nutrients, nitrogen plays a key role for the plant growth. Nitrogen deficiency is frequently a major limiting factor for high yielding crops all over the world (Namvar et al 2013). It is the most limiting nutrient in North Gujarat soils which are loamy sand, having high infiltration and percolation rate that leads to leaching of nitrogen through irrigation water. Nitrogen plays an important role in plant metabolism by virtue of being an essential constituent of structural cell, synthesis of chlorophyll as well as amino acids, which contribute to the building unit of protein and thus growth of plant. The deficiency of nitrogen causes chlorosis, reduction in growth rate and often early senescence of older leaves, leading to yield losses (Caliskan et al 2008, Erman et al 2011). Thus, there is a need to apply nitrogenous fertilizer in the nitrogen deficient soils to overcome the deficiency of nitrogen and to harness higher yield of chickpea.

MATERIAL AND METHODS

Field experiment was carried out during winter (*rabi)* season of 2021-22 at S.D. Agricultural University,

Sardarkrushinagar. The site is geographically situated at 24° 19' N Latitude and 72° 19' E Longitude with an elevation of 154.52 m above the mean sea level. The region is characterised by tropical and semi-arid with dry winter (November-February) and soil is loamy sand in texture having low in organic carbon (0.21%) and available nitrogen (168.4 kg/ha) and medium in available phosphorus (35.22 kg/ha) and available potassium (264.10 kg/ha). Chickpea variety "Gujarat Gram 5" was sown manually on 22nd November 2021 with recommended dose of fertilizer was 20:40:00 NPK kg/ha. The experiment was laid out in a split plot design with four replications, consisting of nine treatment combinations comprising three irrigation levels in main plot *viz*., 0.6, 0.8 and 1.0 IW/CPE ratio (I_3) with 50 mm depth of irrigation water at each irrigation and three nitrogen levels in sub plot *viz*., 125%), 100% and 75% RDN One common pre sowing irrigation was applied for crop establishment in all treatments thereafter; 50 mm depth of irrigation water was given through flood method as per the treatment wise. Full dose of phosphorus was applied as basal dose through SSP and nitrogen was given in two splits at half in basal and remaining half at 30 DAS as per the treatment wise. Total nitrogen content from seed and straw samples was determined by using Micro Kjeldahl's method (Jackson 1967). Phosphorus was determined by Vanadomolybdo phosphoric acid yellow colour method using HNO3 system as described by Jackson (1967). Potassium was determined by the method of Flame Photometer (Jackson 1967). The uptake of N, P and K was calculated by using following equation.

Nutrient uptake (kg/ha) =

$$\frac{\left(\text{Content in seed (\%)} \times \text{Seed yield (kg/ha)}\right) + \left(\text{Content in straw (\%)} \times \text{Straw yield (kg/ha)}\right)}{100}$$

Initial and final nutrient status of soil were determined in experimental treatment plot from 0-15 cm depth as per the slandered procedure.

Multiple Linear Regression used to analyse a dependent variable against several independent/predictor variables. This kind of regression is often used due to the reality of some process is not only built by one factor instead, but several other factors are also involved in every activity. The linear regression formula's slope can also be interpreted as the linear relationship strength between the independent variable and its dependent variable.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots + \beta_i X_i$$

Y: Dependent variable, βo: Intercept, β_1: Slop for Xi, X: Independent variable SPSS software used for data analysis

RESULTS AND DISCUSSION

Seed and straw yield: Irrigation scheduled at 1.0 IW/CPE ratio recorded significantly the highest seed yield (2306 kg/ha) and straw yield (3123 kg/ha) of chickpea which was at par with 0.8 IW/CPE ratio and significantly superior over 06 IW/CPE ratio (Table 1). Increase in irrigation frequency from 0.6 to 1.0 IW/CPE ratio increase consumptive use of water, which provided congenial condition throughout the growth period of the crop. Besides adequate soil moisture in the rhizosphere of chickpea crop which results in higher photosynthesis and translocation of photosynthesis towards reproductive structures. Several researchers reported improved seed yield with irrigation scheduled at 0.8 and 1.0 IW/CPE (Pawar et al 2013, Kumbhar et al 2015, Srinivasulu et al 2016, Khot et al 2021). Application of 125% RDN recorded significantly the highest seed yield (2213 kg/ha) and straw yield (3068 kg/ha) which was at par with 100% RDN. The improvement in yield components might have resulted from favourable influence of nitrogen on growth attributes and efficient and greater partitioning of metabolites and adequate translocation of nutrients to developing reproductive structure. The results agreed with Bhadoria (2018), Dwivedi et al (2019) and Verma et al (2019).

Quality: Protein content in chickpea were significantly influenced by irrigation and nitrogen levels (Table 1). With each unit of increased in irrigation level from 0.6 to 1.0 IW/CPE. There was significant increase in protein content. Highest value of protein content (21.78%) and protein yield (503 kg/ha) was with 1.0 IW/CPE ratio which was at par with 0.8 IW/CPE ratio and significantly superior over 0.6 IW/CPE ratio. This might be due to better plant growth at optimum irrigation level, hence more dry matter production resulting dilution of nitrogen under increased moisture supply resulted more accumulation of protein in seed and higher seed yield. Mehta et al (2010) also reported similar results. The increase in levels of nitrogen levels from 75% to 125%, boosted the protein content and protein yield of chickpea up to the highest nitrogen level. The maximum values of protein content (21.40%) and protein yield (475 kg/ha) in chickpea seed were recorded under 125% RDN. However, it was at par with 100% RDN and significantly superior 75% RDN. This increase in protein content may be attributed to increased concentration of nitrogen in seed and higher seed yield of chickpea due to application of nitrogen fertilizers. Similar results were reported by Bonde and Gawande (2017) and Singh and Singh (2017). The applied water in chickpea was found to be significantly and positively correlated to protein content in seed and protein yield of chickpea. The higher level of irrigation from 0.6 to 1.0 IW/CPE ratio, increased growth of plant at optimum moisture levels and enhanced nutrient

content and uptake seed which ultimately affected on protein yield. Similarly the increase in nitrogen levels from 75 to 125%, showed curvilinear increase in protein content in seed and protein yield due to better uptake of nitrogen in seed and higher seed yield. The relationship between applied water and nitrogen levels with protein content and protein yield was curvilinear (polynomial of first order) (Fig. 1 and 2). This relationship could be expressed as follows:

$y = -3E - 0.05x^2 + 0.0409x - 9.2675$ ($R^2 = 0.99$) ..... Eq. 1

$y = -0.0037x^2 + 4.22x - 683.63$ ($R^2 = 0.99$) ..... Eq. 2

Nutrient Content and Uptake

Nutrient content: The irrigation scheduling exhibited significant difference on nitrogen content in seed and straw of chickpea (Table 2). This was nonsignificant in the phosphorus and potassium content. Significantly higher nitrogen content in seed (3.49%) and straw (1.51%) were with irrigation scheduled at 1.0 IW/CPE ratio being at par with 0.8 IW/CPE ratio. This might be due to irrigation at higher levels created better environment for availability of moisture eventually increases the nitrogen uptake, increasing the amount of protein and therefore, the amount of protoplasm (Yasari and Patwardhan 2006). This increase in term, results in greater cell size and leaf area, vigorous root growth, higher uptake and thus in greater photosynthetic activity. The present findings are in line with Emamzada (2015) and Bhadoria (2018). The significantly higher nitrogen content in seed (3.42%) and straw (1.50%) were recorded under 125% RDN which remained statistically at par with 100% RDN. Phosphorus and potassium content in seed and straw did not differ significantly. Nitrogen content in seed and straw of a chickpea was relatively higher with increase in level of nitrogen. Since the concentration of nitrogen and dry matter production increased with nitrogen application, the uptake of nutrient also increased. It is because of the ability of nitrogen to more towards reproductive organs. Similar findings were reported by Kumar et al (2014) and Verma et al (2020).

Nutrient Uptake: Nutrients (N, P and K) uptake by chickpea

Table 1: Effect of irrigation scheduling and nitrogen levels on yield and nutrients content of chickpea

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)	FWUE (kg/ha/mm)
Irrigation scheduling: (I)					
I_1: 0.6 IW/CPE ratio	1715	2660	19.54	334	4.90
I_2: 0.8 IW/CPE ratio	2173	2953	20.99	455	4.83
I_3: 1.0 IW/CPE ratio	2306	3123	21.78	504	4.19
CD (p=0.05)	357.6	265.9	1.58	47.90	-
Nitrogen levels: (N)					
N_1: 125% RDN	2213	3068	21.40	475	4.92
N_2: 100% RDN	2142	2927	21.20	454	4.76
N_3: 75% RDN	1839	2742	19.70	364	4.09
CD (p=0.05)	160.4	248.9	1.40	34.80	-

Table 2. Effect of irrigation scheduling and nitrogen levels on nutrients content and uptake and available soil status after harvest of chickpea

Treatment	N content (%)		P content (%)		K content (%)		N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Nutrient status in soil after harvest (kg/ha)		
	Seed	Straw	Seed	Straw	Seed	Straw						
Irrigation scheduling: (I)												
I_1: 0.6 IW/CPE ratio	3.13	1.35	0.56	0.30	0.77	1.23	89.59	17.58	45.92	154.0	33.46	231.1
I_2: 0.8 IW/CPE ratio	3.36	1.47	0.58	0.31	0.80	1.26	116.4	21.76	54.59	151.2	32.64	222.3
I_3: 1.0 IW/CPE ratio	3.49	1.51	0.61	0.33	0.83	1.29	127.6	24.37	59.43	146.6	28.82	211.3
CD (p=0.05)	0.25	0.06	NS	NS	NS	NS	8.12	3.05	3.36	NS	NS	NS
Nitrogen levels: (N)												
N_1: 125% RDN	3.42	1.50	0.60	0.32	0.81	1.28	121.7	23.10	57.20	155.0	30.94	214.7
N_2: 100% RDN	3.39	1.48	0.59	0.31	0.80	1.26	115.9	21.71	54.02	151.6	31.58	221.5
N_3: 75% RDN	3.15	1.36	0.56	0.31	0.78	1.24	95.22	18.80	48.35	145.2	32.39	228.4
CD (p=0.05)	0.22	0.09	NS	NS	NS	NS	5.75	1.24	3.69	7.86	NS	NS

crop under varying irrigation schedules on were significant (Table 2). Significantly higher N, P and K uptake by crop (127.6, 24.37 and 59.43 kg/ha, respectively) were with irrigation scheduled at 1.0 IW/CPE ratio being at par with 0.8 IW/CPE ratio. This might be due to better availability of moisture and availability of nutrients throughout the growth stages, leading to better uptake of nutrients. Since most of the nutrients taken up by chickpea is in water soluble form, better availability of moisture could have increased root growth and thus increased absorption of nutrients, it might have increased mobilization of nutrients and thereby increased its availability to the plants and might have increased the availability of plant root to absorb nutrients by affecting the metabolic activity of the plant. Sodavadiya (2017) and Bhadoria (2018) also reported similar trend. Total nutrients uptake by chickpea were influenced significantly due to different nitrogen levels. Significantly higher N, P and K uptake by crop (121.7, 23.10 and 57.20 kg/ha, respectively) were recorded under 125% RDN being at par with 100% RDN. This might be due to higher nitrogen application produced significantly higher seed yield and higher nutrient content than lower nitrogen doses that finally leads to higher nutrient uptake by chickpea. This indicates that uptake of nutrients is directly proportional to the seed and straw yield of chickpea crop. These results are in accordance with findings of Kumar (2014) and Pancholi (2020). The applied water in chickpea indicated significantly positively correlation to nutrient uptake (Fig. 3). The regression coefficient of applied water on NPK uptake was 0.946, 0.973 and 0.982, respectively. Similarly applied nitrogen levels had significant and positive association between with nutrient uptake and coefficient of determination was 0.904, 0.974, 0.960, respectively (Fig. 4).

Nutrient status in soil after harvest: The different irrigation scheduling did not show any significant difference in available nutrients in soil after harvest of crop. The significantly highest N status in soil after harvest (155.0 kg/ha) was obtained when the crop was fertilized with 125% RDN which was at par with 100% RDN. The available phosphorus and potassium status in soil after harvest of crop were not influenced significantly due to the nitrogen levels. The increase in available nitrogen status in soil might be

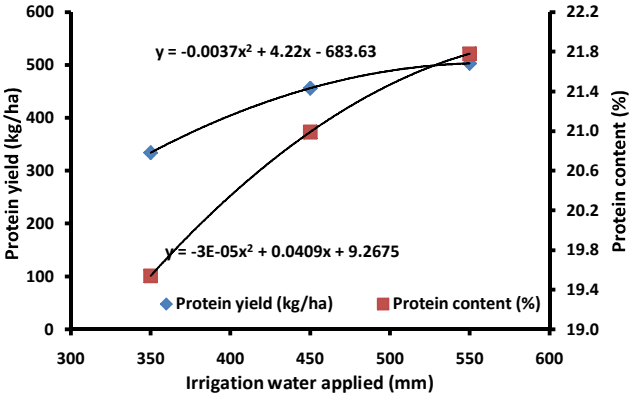

Fig. 1. Relationship of irrigation water applied to protein content and protein yield

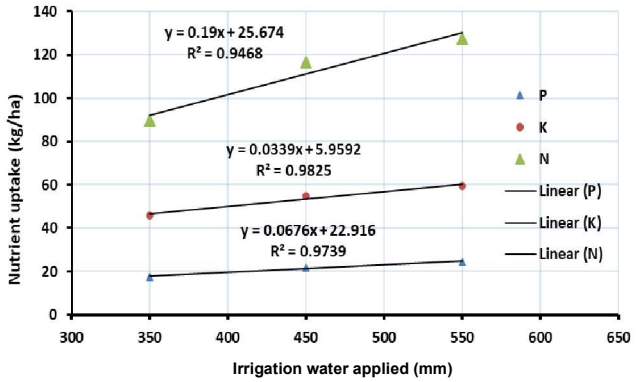

Fig. 3. Relationship of irrigation applied water with NPK nutrient uptake

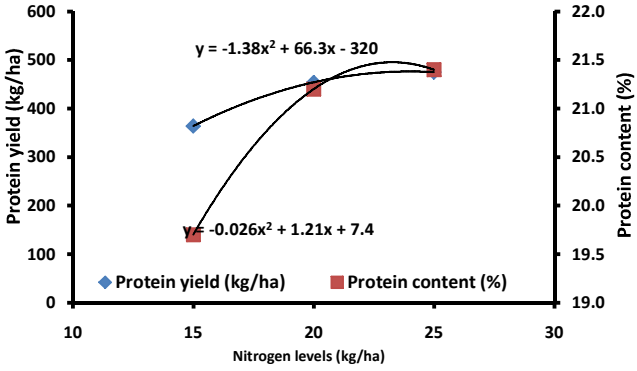

Fig. 2. Relationship of nitrogen levels to protein content and protein yield

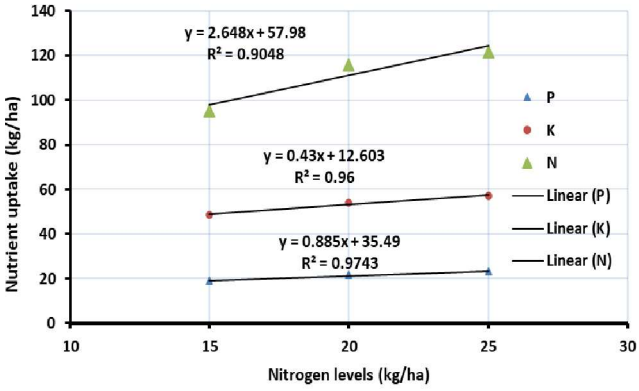

Fig. 4. Relationship of applied nitrogen levels with NPK nutrient uptake

Table 3. Seed yield and total nitrogen uptake of chickpea as influenced by interaction between irrigation scheduling and nitrogen levels

Irrigation scheduling	Seed yield (kg/ha)			Total nitrogen uptake (kg/ha)		
	N_1: 125% RDN	N_2: 100% RDN	N_3: 75% RDN	N_1: 125% RDN	N_2: 100% RDN	N_3: 75% RDN
I_1: 0.6 IW/CPE ratio	1734	1711	1702	94.17	91.71	82.00
I_2: 0.8 IW/CPE ratio	2384	2280	1854	129.4	120.7	98.59
I_3: 1.0 IW/CPE ratio	2521	2436	1961	142.8	135.0	105.8
CD (p=0.05)		277.8			9.95	

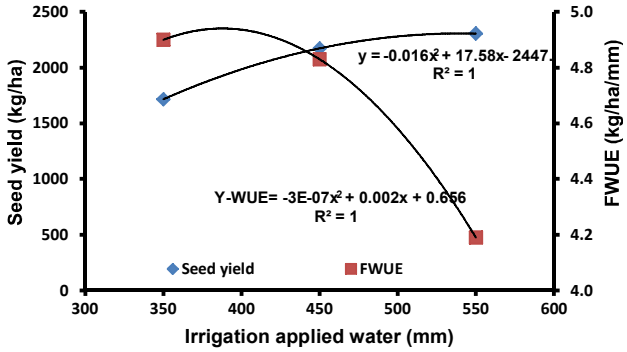

Fig. 5. Relationship of irrigation water applied to seed yield and water use efficiency

attributed to the increased application of nitrogen in soil and plants cannot utilize the excessive nitrogen content from soil solution. Pancholi (2020) reported higher available soil N after harvest of chickpea under higher nitrogen dose.

Interaction effect between irrigation scheduling and nitrogen levels: The irrigation scheduled at 1.0 IW/CPE ratio along with application of 125% RDN recorded significantly higher seed yield (2521 kg/ha) and total nitrogen uptake (142.8 kg/ha) by chickpea which was at par with irrigation scheduled at 1.00IW/CPE along with 100% RDN, 0.8 IW/CPE and along with 125% RDN and 0.8 IW/CPE with 100% RDN which were significantly superior over rest of treatments (Table 3). The results agree with the Gadade et al (2021). The crop fertilized with nitrogen along with adequate amount of irrigation can increased in nitrogen uptake by plant. Nitrogen accumulation during vegetative growth period, which was conducive to transfer to seed at maturity stage improved dry matter accumulation at harvest and ultimately seed yield.

Yield water use efficiency (Y-WUE): Y-WUE was significantly affected by irrigation water applied during experimental period. Each higher level of irrigation from 0.6 to 1.0 IW/CPE ratio decreased water use efficiency of chickpea. Numerically, highest water use efficiency (4.90 kg/ha/mm) was recorded at 0.6 IW/CPE ratio. The relationship between Y-WUE was curvilinear (polynomial of second order) (Fig. 5). This relationship could be expressed as follows:

$$Y - WUE = -3E - 07\,x^2 + 0.002\,x + 0.656\ (R^2 = 0.99)$$

Y-WUE increased with increasing water shortage in the root zone, indicating that yield losses was proportionally smaller than the amount of water used by crops. The different effects of water deficit on Y-WUE observed in various studies can be attributed to the level of water stress experienced by the crop. Chickpea crop develop deep root system which potentially increases the water availability for the plants and attenuates negative effects of water deficit. This may bring up the crop more resistant to water stress and a greater Y-WUE. In the shallow soils, as in experiment, the development of the rooting system was very limited and resulted in severe water stress with a very negative impact on the yield and Y-WUE. The application of each higher level of nitrogen improved Y-WUE, as well as yield, in agreement with results reported by Gadade et al (2021).

CONCLUSIONS

The remunerative higher yield of chickpea can be achieved by irrigation scheduled at 0.8 IW/CPE ratio along with application of 100% recommended dose of nitrogen (20 kg/ha) in sandy loam soil of North Gujarat. Each unit increase in irrigation and nitrogen level from lower to higher levels, there was significantly increased nutrient content, nutrient uptake, protein content in seed and protein yield. Relationship between irrigation water applied and nitrogen levels with seed yield, FWUE, nutrient content and uptake, protein content in seed and protein yield was highly significant and coefficient of determination >90% indicate strong relationship between them.

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