Annals of Plant and Soil Research 24(2):282-287 (2022)
https://doi.org/10.47815/apsr.2022.10162

Effect of irrigation and nitrogen on yield and water productivity of groundnut (*Arachis hypogaea*) and clusterbean (*Cyamopsis tetragonoloba*)

RAMESHWR LAL MANDEEWAL[*], M.L. SONI[1], I.J. GULATI, N.D. YADAVA[1], VINAY NANGIYA[2], BIRBAL[1] AND AMIT KUMAWAT

Department of Soil Science and Agricultural Chemistry, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan – 334006

Received: December, 2021; Revised accepted: February, 2022

ABSTRACT

An experiment was carried out at village Bajju, Bikaner, (Rajasthan) during kharif season of 2016 to evaluate the effect of irrigation and nitrogen levels on groundnut and clusterbean. The treatments comprised of 3 levels of irrigation i.e. 250, 500 and 700 mm for groundnut and 100, 200 an 300 mm for clusterbean and 4 levels of nitrogen i.e. 0, 20, 40 and 60 kg N ha^{-1} for both the crops. These treatments were evaluated in split plot design with four replications. The results showed that increasing levels of irrigation had significant beneficial influence on the kernel/pod/seed and haulm/stover yield, nitrogen uptake by kernel/seed and haulm/stover and water productivity of groundnut and clusterbean. Application of nitrogen levels significantly enhanced the kernel/pod/seed and haulm/stover yield, nitrogen uptake by both the crops and total water productivity of groundnut and clusterbean. The increase in kernel, pod and haulm yield of groundnut with 40 kg N ha^{-1} were 49.6, 57.0 and 39.3 per cent over control and 15.9, 15.6 and 14.7 per cent over 20 kg N ha^{-1}, respectively. Similarly, the increase in seed and straw yield of clusterbean with 40 kg N ha^{-1} were 47.3 and 37.2 per cent over control and 14.0 and 14.1 per cent over 20 kg N ha^{-1}, respectively. Interaction of irrigation and nitrogen had significant beneficial effect on yield, nitrogen uptake and water productivity of groundnut and clusterbean and maximum values of these parameters were recorded under I_3 N_3 treatment in both the crops.

Keywords- Clusterbean, groundnut, irrigation, nitrogen, water productivity, yield

INTRODUCTION

Groundnut and cluster bean are the major kharif season crops of IGNP stage II. These crops not only play a great role in economic growth of the farmers of this region, but also contribute a lot in India's economy. Groundnut (*Arachis hypogaea* L.) is an important oilseed crop and it is a primary source of edible oil and has a high oil (44-50%) and protein content (25%) and also a valuable source of vitamins E, K and B. Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] Commonly known as guar, is an important drought hardy leguminous crop. Clusterbean is mostly cultivated in arid and semi arid regions of India and has a deep tap root system that can find moisture deep below the soil surface thus offer better scope for rainfed cropping system. Effective management of water for crop production in water scarce areas requires efficient approaches for improving water productivity. These include effective management practices, growing high value water efficient crops and cropping systems. The crops grown in *Indira Gandhi Nahar Pariyojana* (IGNP) stage II are high water requiring and farmers use excess irrigation for growing the crops but the concept of water productivity is based on "producing more food from the same water resources" or "producing the same amount of food from less water resources". In a broad sense, productivity of water is related to the value or benefit derived from the use of water. It includes various aspects of water management and is very relevant for arid and semi-arid regions. Therefore, technological interventions are required to improve crop water productivity of the area. It is well known fact that crop production largely depends on need based application of nutrients and for maximizing the yield, it is essential that crops should not suffer to inadequate moisture supply and mineral nutrition especially nitrogen. Nitrogen is such a star nutrient in crop production that it can never be ignored. Among all nutrients, crop demand for nitrogen is greatest because it is a major structural constituent of cell, protein and enzymes and plays an important role in growth,

Corresponding author email: rameshwermandiwal@gmail.com, [2]ICAR- Central Arid Zone Research Institute, Regional Research Station, Bikaner, Rajasthan, [3]Senior hydrologist ICARDA, Jordan

yield and quality of crops. All plants need nitrogen to grow, develop leaves and branches, carry out photosynthesis and produce proteins which are compounds of nitrogen. Moreover, the level of nitrogen fertilization and irrigation is very important to increase the fertilizer efficiency, decrease the loss of water and improve water productivity without compromising the crop yield. The information regarding effects of irrigation and nitrogen rates and their interaction on yield and water productivity of groundnut and cluster bean is scanty. Therefore, the present study was under taken using groundnut and clusterbean as test crops.

MATERIALS AND METHODS

An experiment was carried out during *kharif* season of 2016 at village Bajju, (072°47’79”E longitude and 28°14’23”N latitude and 234.7 m above mean sea) Bikaner, Rajasthan, India. The climate of this zone is typically arid characterized by aridity of the atmosphere and slight salinity in the rhizosphere with extremes of temperature both in summers and winters. The soils of the area are loamy sand in texture and slightly alkaline in reaction (pH 8.1) with low in organic matter (1.3 g kg^{-1}), available nitrogen (114.5 kg ha^{-1}), medium in available phosphorus (15.9 kg ha^{-1}) and potassium (189.2 kg ha^{-1}). The field experiment was laid out with 3 levels of irrigation i.e. 250, 500 and 700 mm for groundnut and 100, 200 an 300 mm for clusterbean and 4 levels of nitrogen i.e. 0, 20, 40 and 60 kg N ha^{-1} for both the crops comprising a total of 12 treatment combinations in split plot design with four replications. The seed of groundnut variety GG-20 was sown using 100 kg seed ha^{-1} on 30th June, 2016 and cluster bean variety RGC-1038 was sown using 15 kg seed ha^{-1} on 13th July 2016. Urea was used as the source of nitrogen and half dose of nitrogen was applied as a basal dose prior to sowing. The remaining half dose of nitrogen was top dressed at first irrigation. The groundnut crop was harvested on 3rd November 2016 and clusterbean on 30th October 2016. The samples of groundnut and clusterbean crops were analyzed for nitrogen content by Kjeldahl method. Nitrogen uptake was calculated by multiplying nitrogen content in kernel/seed and haulm/stover with respective yields. Water productivity was calculated separately in terms of evapotranspiration (dividing yield by ET) and in terms of water applied (dividing yield by total water applied through irrigation and rainfall). In order to test the significance of variance in experiments, the data obtained for various treatment effects were statistically analyzed as per procedure described by Panse and Sukhatme (1985) for split plot design.

RESULTS AND DISCUSSION

Effect of irrigation

Yield: Increasing levels of irrigation from 250 mm to 700 mm significantly increased the kernel yield (1801 kg ha^{-1}), pod yield (2848 kg ha^{-1}), haulm yield (3964 kg ha^{-1}) and biological yield (6813 kg ha^{-1}) of groundnut. On the other hand, in clusterbean successive increase in irrigation level up to 200 mm significantly increased the seed yield (951 kg ha^{-1}), stover yield (2458 kg ha^{-1}) and biological yield (3409 kg ha^{-1}) over 100 mm irrigation but remained at par with 300 mm irrigation level. Significantly higher yield of both the crops with irrigation might be owing to the availability of optimum moisture in the root zone of crops through small and repeated irrigation which checks percolation losses beyond the root zone depth and prevent drying up of upper soil layers thus ensure proper conditions for maximum utilization of soil available nutrients and applied fertilizer nitrogen. Optimum moisture condition in the root zone of soil influences the nodulation and availability of different nutrients and helps in achieving better plant growth and yield. The results are in closely conformity with the findings of Mondal *et al.* (2018), Karande *et al.* (2019) and Kumar *et al.* (2020).

Water productivity: Water productivity increased significantly with the successive increase in the levels of irrigation in terms of evapo-transpiration (WP_{ET}) in both the crops. Significantly highest WP_{ET} was recorded with 700 mm level of irrigation in groundnut and 300 mm level of irrigation in clusterbean. This could be due to the fact that the yield produced in higher levels of irrigation is in proportionate to water used by the crop. Giri *et al.* (2014) and Singh *et al.* (2017) found similar type of results. While, the water productivity in terms of water applied (WP_{WA}) decreased significantly with the successive increase in levels of irrigation and maximum WP_{WA} was observed with 250 mm irrigation level in groundnut and 100 mm irrigation level in clusterbean. The decrease in water productivity (in terms of water applied) with increasing irrigation levels has been reported by Abdulmohsin *et al.*, (2018) in mungbean and Kumar *et al.* (2020) in clusterbean.

Table 1: Effect of irrigation and nitrogen levels on yield, water productivity and nitrogen uptake by groundnut

Treatments	Yield (kg ha^{-1})				Water productivity (kg m-3)		N uptake (kg ha^{-1})	
	Kernel	Pod	Haulm	Biological	In terms of ET	In terms of WA	Kernel	Haulm
Irrigation (mm)								
I_1 250	1224	1814	2841	4655	0.29	0.32	41.8	25.9
I_2 500	1567	2463	3573	6036	0.39	0.30	54.9	33.5
I_3 700	1801	2848	3964	6813	0.45	0.28	63.5	39.1
CD (P=0.05)	119	294	246	349	0.047	0.041	5.9	4.0
Nitrogen (kg ha^{-1})								
N_0 20	1141	1906	2752	4658	0.30	0.24	36.6	22.4
N_1 20	1473	2266	3341	5607	0.36	0.29	50.2	30.5
N_2 40	1707	2622	3833	6455	0.42	0.33	61.5	38.1
N_3 60	1802	2707	3911	6618	0.43	0.34	65.2	40.3
CD (P=0.05)	119	142	260	331	0.023	0.018	36.6	22.4
Interaction								
I_1N_0	1029	1664	2650	4313	0.27	0.30	34.3	19.7
I_1N_1	1136	1795	2760	4554	0.29	0.32	38.6	25.6
I_1N_2	1296	1873	2935	4808	0.30	0.34	43.9	29.2
I_1N_3	1435	1926	3018	4944	0.31	0.35	50.2	29.3
I_2N_0	1083	1818	2751	4569	0.29	0.23	33.4	23.6
I_2N_1	1592	2389	3477	5866	0.38	0.30	53.7	31.7
I_2N_2	1776	2786	4021	6807	0.45	0.35	65.6	39.1
I_2N_3	1818	2859	4044	6902	0.46	0.35	67.1	39.6
I_3N_0	1310	2237	2856	5092	0.36	0.22	42.1	24.1
I_3N_1	1692	2614	3786	6400	0.42	0.26	58.3	34.2
I_3N_2	2050	3206	4543	7749	0.52	0.32	75.1	46.1
I_3N_3	2152	3337	4672	8009	0.54	0.33	78.3	52.0
CD (P=0.05)	206	245	450	573	0.04	0.03	8.4	6.2

Nitrogen uptake: Successive increase in irrigation up to 700 mm significantly increased nitrogen uptake by kernel and haulm of groundnut over 250 mm and 500 mm irrigation level while increasing level of irrigation from 100 mm to 200 mm also increased the nitrogen uptake by seed and stover of clusterbean but remained at par with 300 mm. The increase in nitrogen uptake due to 700 mm irrigation was 51.9 and 15.5 per cent by kernel and 50.7 and 16.6 per cent by haulm of groundnut over 250 mm and 500 mm irrigation level, respectively. While, the increase in nitrogen uptake due to 200 mm irrigation was 35.7 per cent by seed and 33.7 per cent by stover over 100 mm levels of irrigation. The increased nitrogen uptake in crop could be ascribed to more availability of moisture in rhizosphere which resulted in better root proliferation and might have improved availability of nutrients particularly nitrogen. Similar results were also observed by Singh *et al.* (2017) and Swetha and Hussain (2017).

Effect of nitrogen

Yield: Increase in level of nitrogen up to 40 kg N ha^{-1} significantly increased the kernel, pod, haulm and biological yield of groundnut and seed, stover and biological yield of clusterbean as compared to control and 20 kg N ha^{-1}, respectively. Beyond this level, yield did not increase significantly over 40 kg N ha^{-1}. Application of 40 kg N ha^{-1} in groundnut increased the kernel yield by 49.6 and 15.9 per cent, the pod yield by 37.6 and 15.7 per cent, the haulm yield by 39.3 and 14.7 per cent and the biological yield by 38.6 and 15.1 per cent over control and 20 kg N ha^{-1}, respectively. While, in clusterbean, the application of 40 kg N ha^{-1} increased the seed yield by 47.3 and 14.1 per cent, the straw yield by 37.2 and 14.1 per cent and the biological yield by 39.9 and 14.1 per cent over control and 20 kg N ha^{-1}, respectively. Since yield is the resultant of additive and complementary effect of plant growth and yield

attributing parameters and the yield attributing characters had better expression at 40 kg N ha^{-1} which ultimately led towards an increase in pod/seed and stover/haulm yields. Under the higher supply of nitrogen, crops synthesized more photosynthates and the storage organ was better developed. Nitrogen is closely linked to control the vegetative growth of plant and hence determines the fate of reproductive cycle. The increases in yield as a result of nitrogen application have also been reported by Rawat *et al.* (2013), Kumar *et al.* (2014), Patel *et al.* (2015) and Kumar (2017).

Table 2: Effect of irrigation and nitrogen levels on yield, water productivity and nitrogen uptake by clusterbean

Treatments	Yield (kg ha^{-1})			Water productivity (kg m-3)		N uptake (kg ha^{-1})	
	Seed	Stover	Biological	In terms of ET	In terms of WA	Seed	Stover
Irrigation (mm)							
I_1 100	714	1942	2655	0.34	0.31	20.8	10.3
I_2 200	951	2458	3409	0.45	0.29	28.2	13.8
I_3 300	1018	2649	3666	0.49	0.24	30.1	14.7
CD (P=0.05)	111	255	356	0.053	0.030	4.5	3.0
Nitrogen (kg ha^{-1})							
N_0 20	676	1877	2553	0.33	0.21	18.0	8.4
N_1 20	873	2257	3130	0.42	0.27	25.0	11.9
N_2 40	996	2576	3572	0.48	0.31	30.6	15.2
N_3 60	1031	2689	3720	0.50	0.32	31.8	16.3
CD (P=0.05)	74	230	295	0.036	0.021	3.0	1.9
Interaction							
I_1N_0	594	1921	2515	0.29	0.26	16.4	8.7
I_1N_1	725	1874	2598	0.35	0.31	21.1	10.0
I_1N_2	758	1961	2719	0.37	0.33	22.5	11.1
I_1N_3	778	2012	2790	0.38	0.34	23.0	11.4
I_2N_0	696	1800	2496	0.34	0.21	18.3	8.2
I_2N_1	878	2271	3149	0.42	0.27	24.6	11.7
I_2N_2	1079	2789	3868	0.52	0.33	33.5	16.8
I_2N_3	1150	2974	4124	0.56	0.35	36.2	18.3
I_3N_0	738	1909	2648	0.36	0.17	19.2	8.3
I_3N_1	1016	2626	3642	0.49	0.24	29.4	13.8
I_3N_2	1152	2978	4129	0.56	0.27	35.8	17.6
I_3N_3	1165	3082	4247	0.56	0.27	36.2	19.1
CD (P=0.05)	129	399	510	0.062	0.03	5.1	3.3

Water productivity: Increasing levels of nitrogen significantly increased water productivity in terms of evapo-transpiration (WP_{ET}) and water applied (WP_{WA}). Application of 40 kg N ha^{-1} significantly improved water productivity in terms of evapo-transpiration (WP_{ET}) and water applied (WP_{WA}) over control and 20 kg N ha^{-1} but it remained at par with 60 kg N ha^{-1} (Table 1 and 2). The improvement in water productivity with an increase in nitrogen fertilization might be attributed to increased leaf area which leads to reduction in evaporation component of evapotranspiration, smaller increase in evapotranspiration compared to yield and better utilization of available soil water. The results were in agreement with the findings of Kumar *et al.,* (2020).

Nitrogen uptake: Nitrogen uptake by kernel/seed, haulm/stover and total plant of groundnut and clusterbean significantly increased with application of nitrogen up to 40 kg N ha^{-1} over control and 20 kg N ha^{-1}. Improvement in the nutritional environment of the root zone might have helped in development of better root system leading to absorption of more and more nutrients from soil compared with control. Increased availability of nitrogen in the root zone stimulated its uptake by the crops, which translocated to various plant parts due to

increased metabolic activities at cellular level. Since nutrient uptake is a function of nutrient content of plant and total dry matter of the crop in terms of kernel/seed and haulm/stover yields, application of nitrogen up to 40 kg ha^{-1} increased the uptake of nitrogen significantly. Significant improvement in nitrogen uptake due to nitrogen application was observed by Kumar *et al.* (2014) and Kumar (2017).

Interaction: Interaction effect of irrigation and nitrogen on yield, nitrogen uptake and water productivity of groundnut and clusterbean was found-significant. At all the levels of nitrogen application, the yields and nitrogen uptake by groundnut increased significantly with the increase in irrigation from 250 mm to 700 mm. On the other hand, increase in levels of irrigation increased the yields and nitrogen uptake by clusterbean from 100 mm to 200 mm, beyond this level increase in all these parameters was non-significant. Similarly, at all the levels of irrigation, increase in levels of nitrogen up to 40 kg N ha^{-1} increased all these parameters which remained statistically at par with 60 kg N ha^{-1}. Irrespective of levels of irrigation and nitrogen, the maximum values were recorded under 700 mm and 300 mm irrigations in combination with 40 kg N ha^{-1} in groundnut and clusterbean, respectively. Furthermore, the highest water productivity was recorded with 700 mm in groundnut and 200 mm irrigation in clusterbean with 40 kg N ha^{-1} in terms of ET and 250 mm in groundnut and 100 mm in clusterbean with 60 kg N ha^{-1} in terms of water applied. These results can be explained by the fact that soils of arid tract of Rajasthan in particular are hungry and thirsty which is evident by the soil nutrient status of the experimental field. Though, the legume crops are considered as self sustained crops due to their nitrogen fixing habit, but poor nutrient status, in general, and nitrogen in particular leads to less nitrogen fixation and poor utilization of this potential of groundnut and cluster bean as a legume crop. Graded levels of irrigation boost the crop growth which further increased the nitrogen demand of the crop. Ahmad *et al.* (2018) and Kumar *et al.* (2020) supported the present findings of increased performance of groundnut and cluster bean with higher irrigation and nitrogen levels.

From the findings, it may be concluded that irrigation and nitrogen levels had significant beneficial effect on yield, nitrogen uptake and water productivity of groundnut and clusterbean. The application of 700 mm irrigation level in groundnut and 200 mm in clusterbean with 40 kg N ha^{-1} was found most promising for getting higher yield, nitrogen uptake and water productivity of groundnut and clusterbean.

REFERENCES

Abdulmohsin, A.S., Fathy, R.N. and Saleh, I.M. (2018) Enhanced mungbean and water productivity under full irrigation and stress using humic acid in arid regions. *Legume Research* **41**(3): 428-431.

Ahmad, P.S., Jaiswal, P.C., Ahmad, P.F., Ahmad, G.S. and Amjad, M. (2018) Effect of different levels of nitrogen and sulphur on growth, nodulation and yield of green gram (*Vigna radiata* L.). *Legume Research* **41**(5): 767-770.

Giri, U., Hedayetullah, M.D., Saha, A., Nanda, M. K. and Bandyopadhyay, P. (2014) Productivity and nutrient uptake of summer groundnut (*Arachis hypogaea* L.) towards different levels of irrigation and sulphur. *Journal of Crop and Weed* **10**(2): 248-251.

Karande, B.I., Patel, H.R., Patil, D.D., Yadav, S.B. and Vasani, M.J. (2019) Influence of irrigation levels and row spacings on yield and yield attributing characters of mungbean varieties (*Vigna radiata* L.) in middle Gujarat Agro-climatic zone. *International Journal of Current Microbiology and Applied Sciences* **8**(2): 464-473.

Kumar, L.S., Radder, B.M., Malligawad I.H. and Manasa V. (2014) Effect of nitrogen and phosphorus levels and ratios on yield and nutrient uptake by groundnut in northern transition zone of Karnataka. *The Bioscan* **9**(4): 1561-1564.

Kumar, R. (2017) Effect of water and nitrogen levels on yield and water productivity of cotton and cluster bean in Indira Gandhi

Nahar Pariyojana (IGNP) stage – I. M. Sc. Thesis submitted in SKRAU, Bikaner.

Kumar, R., Pareek, N.K., Rathore, V.S., Nangiya, V., Yadava, N.D. and Yadav,

R.S. (2020) Effect of water and nitrogen levels on yield attributes, water productivity and economics of cluster bean (*Cyamopsis tetragonoloba*) in hot arid region. *Legume Research* **43**(5): 702-705.

Mondal, R., Ali, J., Biswas, S., Das, S., Dutta, D. and Sarkar, T. (2018) Effect of different levels of irrigation and nutrient on growth and yield of Summer Green gram cv. Bireswar in New Alluvial Zone of West Bengal. *International Journal of Chemical Studies* **6**(1): 386-390.

Panse, V.G. and Sukhatme, P.V. (1985) Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.

Patel, D.R., Patel, V.R., Patel K.M. and Patel N.H. (2015) Effect of nitrogen and sulphur levels on growth, quality and nutrient status of summer clusterbean (*Cyamopsis tetragonoloba* (L.) Taubert). *Trends in Biosciences* **8**(21): 5914-5917.

Rawat, G.S., Rawat, U. and Rajput, R.L. (2013) Effect of nitrogen and time of application on yield attributes and yield of clusterbean (*Cyamopsis tetragonoloba* (L.) Taub) *Bhartiya Krishi Anusandhan Patrika* **28**(2): 82-84.

Singh, R., Kumar, S., Kumar, H., Kumar, M., Kumar, A. and Kumar D. (2017) Effect of irrigation and integrated nutrient management on water use efficiency and nutrient uptake of chickpea (*Cicer arietinum* L.). *Plant Archives* **17**(2): 1453-1456.

Swetha, D. and Hussain, S.A. (2017) Effect of moisture regimes on yield attributes, yield, nutrient uptake and quality of chickpea cultivars (*Cicer arietinum* L.). *International Journal of Current Microbiology and Applied Sciences* 6(9): 3636-3645.