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Research Article

EFFECT OF IRRIGATION SCHEDULING AND NITROGEN MANAGEMENT ON YIELD PARAMETERS, WATER USE EFFICIENCY, NUTRIENT CONTENT AND ECONOMICS OF SUMMER GROUNDNUT (*Arachis hypogaea* L.)

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Abstract: An experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during summer season of the year 2019 to study Effect of irrigation scheduling and nitrogen management on growth and yield of summer groundnut (*Arachis hypogaea* L.). The experiment were four irrigation schedules (IW: CPE ratios 0.4, 0.6 and 0.8 and irrigation at critical growth stages flowering, branching, pod formation and pod development stages) and five nitrogen management treatments were tried. Irrigation level I_2 (0.8 IW: CPE ratio) recorded higher pod yield and haulm yield, nitrogen content in seed and haulm, nitrogen uptake by seed and haulm. The highest water use efficiency was recorded under treatment I_4. Nitrogen management treatment N_3 (50% RDN through chemical fertilizer + 50% RDN through vermicompost) recorded significantly increase pod yield, haulm yield, nitrogen content in seed and haulm, nitrogen uptake by seed and haulm. The treatment combination I_2N_3 recorded higher pod yield, haulm yield, nitrogen uptake by seed and haulm, net realization. Significantly higher WUE was recorded under treatment combination I_4N_3.

Keywords: *Groundnut, Irrigation, Nitrogen, Vermicompost*

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Introduction

Groundnut (*Arachis hypogaea* L.) is known to be a unique and important legume cum oilseed crop of India accounting 33%of world's groundnut area and about 27.3% production. It belongs to Leguminoseae family. It is a multipurpose crop contains high edible oil (45 to 51%) and protein (26%). India is the second largest producer of groundnut in the world which produces around 6.49 million tonnes of groundnut from 4.76 million hectares of land with a productivity of 1550 kg/ha [1]. Gujarat ranks first both in area and production in the country. The area under groundnut is 1.41 million hectares with production of 2.33 million tones and productivity is 1650 kg/ha [2]. Scheduling irrigation to crop is mostly based on physiological growth stage and latest approach of scheduling irrigation through irrigation water depth, cumulative pan evaporation (IW:CPE ratio). It is important for scheduling irrigation to identify the most suitable frequency, time and depth of irrigation for higher yield of groundnut. Nitrogen is also integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. Vermicompost is organic manure produced by earthworm feeding on biological waste material and plant residue. It contains on an average (2.1-2.6%) N, (1.5-1.7%) P and (1.4-1.6%)K. Application of vermicompost showed higher growth and yield attributes, grain yield as well as gross and net returns in groundnut.

Materials and Method

A field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, (Gujarat) during the summer season of the year 2019. Geographically, Anand is situated on 22˚35' N latitude and 72˚55' E longitude, with an elevation of 45.1 m above the mean sea level. The climate of Anand is semi-arid and sub-tropical. The soil of experimental field was loamy sand in texture having good drainage, low in available nitrogen (166.52 kg/ha), low in available phosphorus (44.53 kg/ha) and medium in available potassium (286.28 kg/ha) with 8.15 soil pH.

Groundnut variety Gujarat Groundnut 34 (GG 34) was used as a test crop in the study. The treatment comprising four levels of irrigation (I_1 0.6 : IW: CPE ratio, I_2: 0.8 IW: CPE ratio, I_3: 1.0 IW: CPE ratio and I_4 : irrigation at flowering, branching, pod formation and pod development stages) and five levels of nitrogen management (N_0 : Control, N_1 : 100% RDN through chemical fertilizer, N_2 : 75% RDN through chemical fertilizer + 25% RDN through vermicompost, N_3 : 50% RDN through chemical fertilizer + 50% RDN through vermicompost, N_4 : 100% RDN through vermicompost). Four irrigation treatments were allotted to main plot while five treatments of nitrogen management were embedded as sub plot in split plot design with three replications. Irrigation water of 50 mm (measured with the help of parshall flume) was used to run in each plot at each irrigation. The irrigation treatment was given on the basis of pan evaporation. Daily pan evaporation was measured with the help of USDA Class-A pan evaporimeter installed at the meteorological observatory. Chemical fertilizer was applied through urea and SSP as basal. Entire quantity of vermicompost applied at the time of sowing. Groundnut (GG-34) was sown on 20 February with seed rate 120 kg/ha. The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance [3].

Result and Discussion

Effect of irrigation

Data presented in [Table-1] indicated that application of irrigation at 0.8 IW: CPE ratio (I_2) recorded significantly higher pod yield (3034 kg/ha) and haulm yield (4005 kg/ha) and remain at par with treatment I_3 (1.0 IW: CPE ratio). This might be due to more vigorous crop growth and higher order of yield attributes under frequent irrigations as the atmosphere had high demand of evapo-transpiration during crop period. The results are in close conformity with Lokhande *et al*. (2018) [4] and Balasubramanian *et al*. (2019) [5].

Table-1 Effect of irrigation scheduling and nitrogen management through different sources on pod yield, haulm yield, oil content, water use efficiency and agronomic use efficiency.

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Water use efficiency (kg ha/mm)	Agronomic efficiency
(A) Main plot treatment Irrigation scheduling (I)				
I_1: 0.6 IW:CPE	2657	3570	4.43	-
I_2: 0.8 IW:CPE	3034	4005	4.05	-
I_3: 1.0 IW:CPE	2855	3909	3.17	-
I_4: At branching, flowering,peg formation and pod development	2366	3209	7.89	-
S.Em.±	57.0	94	0.18	
C.D. at 5%	197	323	0.61	-
CV%	8.07	9.85	13.96	-
(B) Sub plot treatment Nitrogen management through different sources (N)				
N_0: Control	2474	3342	4.31	0.00
N_1: 100% RDN through chemical fertilizer	2585	3467	4.59	4.45
N_2: 75% RDN through chemical fertilizer + 25% RDN through vermicompost	2879	3843	5.26	16.20
N_3: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	3086	4163	5.59	24.49
N_4: 100% RDN through vermicompost	2614	3553	4.66	5.60
S.Em.±	56	102	0.13	-
C.D. at 5%	161	294	0.38	-
C.V. %	7.10	9.62	9.37	-
(C) Interaction effect (I × N)	Sig.	Sig.	Sig.	-

Table-5 Effect of irrigation scheduling and nitrogen management through different sources on soil EC, pH and organic carbon, nitrogen, phosphorus and potash content after harvest

Treatment	EC (ds/m)	pH	Organic Carbon (%)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Initial Soil Content	0.18	8.15	0.32	166.52	44.53	286.28
(A) Main plot treatment Irrigation scheduling (I)						
I_1: 0.6 IW:CPE	0.15	8.25	0.35	171.70	45.19	287.42
I_2: 0.8 IW:CPE	0.14	8.26	0.36	178.94	43.21	286.48
I_3: 1.0 IW:CPE	0.15	8.23	0.34	176.67	44.38	286.73
I_4: At branching, flowering, peg formation and pod development	0.15	8.24	0.33	179.49	44.69	286.56
S.Em.±	0.00	0.02	0.00	0.76	0.59	2.37
C.D. at 5%	NS	NS	NS	NS	NS	NS
CV%	7.60	0.85	7.35	3.78	5.88	3.20
(B) Sub plot treatment Nitrogen management through different sources (N)						
N_0: Control	0.14	8.25	0.34	166.09	44.25	285.83
N_1: 100% RDN through chemical fertilizer	0.15	8.24	0.34	173.80	45.02	287.34
N_2: 75% RDN through chemical fertilizer + 25% RDN through vermicompost	0.15	8.24	0.35	175.83	44.81	287.11
N_3: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	0.15	8.24	0.35	179.57	44.64	286.52
N_4: 100% RDN through vermicompost	0.14	8.24	0.35	188.21	44.38	287.19
S.Em.±	0.00	0.02	0.01	1.49	0.67	1.02
C.D. at 5%	NS	NS	NS	2.47	NS	NS
C.V. %	6.89	0.65	5.28	2.92	5.18	1.23
(C) Interaction effect (I × N)	NS	NS	NS	NS	NS	NS

Table-6 Effect of irrigation scheduling and nitrogen management through different sources on N content in seed and haulm and N uptake by seed and haulm after harvest.

Treatment	N content in seed (%)	N uptake by seed (kg/ha)	N content in haulm (%)	N uptake by haulm (kg/ha)
(A) Main plot treatment Irrigation scheduling (I)				
I_1: 0.6 IW:CPE	2.71	44.66	3.06	109.50
I_2: 0.8 IW:CPE	3.12	63.15	3.26	130.67
I_3: 1.0 IW:CPE	3.03	56.67	3.18	124.25
I_4: At branching, flowering, peg formation and pod development	2.56	36.36	2.87	91.35
S.Em.±	0.08	1.81	0.04	3.37
C.D. at 5%	0.28	6.25	0.15	11.67
CV%	11.00	13.94	5.50	11.47
(B) Sub plot treatment Nitrogen management through different sources (N)				
N_0: Control	2.80	44.57	3.11	104.14
N_1: 100% RDN through chemical fertilizer	2.88	48.04	3.04	106.20
N_2: 75% RDN through chemical fertilizer + 25% RDN through vermicompost	2.91	53.61	3.13	120.32
N_3: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	2.86	57.24	3.10	129.78
N_4: 100% RDN through vermicompost	2.81	47.59	3.08	109.27
S.Em.±	0.04	1.09	0.05	3.05
C.D. at 5%	NS	3.14	NS	8.78
C.V. %	5.38	7.51	5.32	9.26
(C) Interaction effect (I × N)	NS	Sig.	NS	Sig.

Table-2 Interaction effect of irrigation scheduling and nitrogen management through different sources on pod yield (kg/ha) of groundnut

Irrigation (I)	Nitrogen sources (N)				
	N_0	N_1	N_2	N_3	N_4
I_1	1910	2631	2855	3170	2714
I_2	2949	2959	3037	3270	2953
I_3	2912	2617	3008	3126	2610
I_4	2036	2133	2703	2778	2179
S.Em.±	112				
C.D. at 5 %	322				

Table-3 Interaction effect of irrigation scheduling and nitrogen management through different sources on haulm yield (kg/ha) of groundnut

Irrigation (I)	Nitrogen sources (N)				
	N_0	N_1	N_2	N_3	N_4
I_1	2636	3379	3914	4387	3535
I_2	3983	3853	4116	4371	3943
I_3	3879	3796	3868	4130	3632
I_4	2737	2837	3606	3762	3104
S.Em.±	204				
C.D. at 5 %	588				

Table-4 Interaction effect of irrigation and nitrogen sources on water use efficiency (kg ha/mm) of groundnut

Irrigation (I)	Nitrogen sources (N)				
	N_0	N_1	N_2	N_3	N_4
I_1	3.18	4.39	4.76	5.28	4.52
I_2	3.93	3.95	4.05	4.36	3.94
I_3	3.24	2.91	3.34	3.47	2.90
I_4	6.79	7.11	9.01	9.26	7.26
S.Em.±	0.26				
C.D. at 5 %	0.76				

The results revealed that WUE was influenced due to different irrigation levels. The highest WUE (7.89 kg ha/mm) was recorded under treatment I_4 (irrigation at B+F+P+P), followed by treatment I_1 (0.6 IW:CPE ratio) and treatment I_2 (0.8 IW: CPE ratio). Water use efficiency (WUE) can be achieved through decreased consumptive use efficiency (Cu) of water. Reduction in WUE when more quantity of water was applied because, in higher moisture regimes more moisture is used for evaporation rather than for production, thereby reducing the water use efficiency. It might be also proportional to the quantity of water used. Maximum WUE was recorded with lower moisture regime. Similar results are observed by Chitodkar *et al*. (2006) [6], Behera *et al*. (2015) [7] and Lokhande *et al*. (2018).

Agronomic use efficiency had no relation with different levels of irrigation.

Results presented in [Table-5] revealed that different irrigation scheduling did not exert significant influence on EC, pH, organic carbon, available nitrogen, available phosphorus and potash content in soil after harvest.

Higher nitrogen content in seed (3.12%) was recorded under treatment I_2 (0.8 IW: CPE ratio), however, it was at par with treatment I_3 (1.0 IW: CPE ratio). From the result, it was observed that, significantly the highest nitrogen uptake (63.15 kg/ha) by seed was recorded with irrigation scheduling I_2 (0.8 IW:CPE ratio).It might be due that when moisture content is more, the rate at which nutrients reach to root surface is high which in turn contributes to high nitrogen uptake. These results are in line with those reported by Chaudhary *et al*. (2015b) [8].

The data [Table-6] revealed that nitrogen content in haulm was influenced due to different irrigation levels. Higher nitrogen content in haulm (3.26%) was recorded under treatment I_2 (0.8 IW: CPE ratio), however, it was remained at par with treatment I_3 (1.0 IW: CPE ratio, 3.18). From the result, significantly higher nitrogen uptake (130.67 kg/ha) by haulm was recorded with irrigation scheduling I_2 (0.8 IW: CPE ratio), which was remained at par with treatment I_3 (1.0 IW: CPE ratio). These might be due to more number of irrigation attributed to higher availability of moisture in the root zone, which enhanced absorption of nutrients. Therefore, it is obvious that when moisture content is more, the rate at which nutrients reach to root surface is high which in turn contributes to high nitrogen uptake. The higher uptake of nitrogen also might be due to higher pod yield under this level of irrigation. These results are in line with those reported by Behera *et al*. (2015).

Table-7 Interaction effect of on nitrogen uptake in seed (kg/ha) of groundnut

Irrigation (I)	Nitrogen sources (N)				
	N_0	N_1	N_2	N_3	N_4
I_1	32.37	44.46	48.26	54.42	43.78
I_2	60.91	62.14	62.37	68.27	62.06
I_3	54.80	50.67	61.37	65.30	51.19
I_4	28.75	34.89	43.89	40.96	33.00
S.Em.±	2.18				
C.D. at 5 %	6.27				

Table-8 Interaction effect of irrigation and nitrogen management on nitrogen uptake by haulm (kg/ha) of groundnut

Irrigation (I)	Nitrogen sources (N)				
	N_0	N_1	N_2	N_3	N_4
I_1	78.17	99.54	122.59	137.35	109.82
I_2	125.33	130.11	134.45	146.96	129.03
I_3	118.89	117.56	126.49	134.44	111.34
I_4	85.04	82.37	102.11	100.35	86.89
S.Em.±	6.09				
C.D. at 5 %	17.55				

Effect of nitrogen management

Data present in [Table-1] with respect to pod yield and haulm yield as influenced by nitrogen management through different sources indicated that significantly the highest pod yield (3086 kg/ha) and haulm yield (4163 kg/ha) were recorded under treatment N_3 (50% RDN through chemical fertilizer + 50% RDN through vermicompost). This might be due to synergistic relation between nutrients, increased vigorous growth of plant as well as more nutrient uptake which improved overall growth of plant and development of the floral primordial. Proper fertilization coupled with increased net photosynthesis on the one hand and greater mobilization of photosynthates towards reproductive structures on the other hand, which might have increased the yield attributes. Similar results were obtained by Bhosle *et al*. (2017) [9].

Nitrogen level N_3 (50% RDN through chemical fertilizer + 50% RDN through vermicompost) recorded significantly higher WUE (5.59 kg ha/mm), which was remain at par with treatment N_2 (75% RDN through chemical fertilizer + 25% RDN through vermicompost). The reason might be due to increase in yield attributes to more vigorous crop growth and higher order of yield attributes under frequent irrigation with adequate supply of nutrients thorough vermicompost application as the atmosphere had high demand of evapo-transpiration and nutrient during crop period which resulted in increased seed yield. Another reason might be due to the higher organic matter resulted in increased water holding capacity of soil which ultimately increase yield, resulted in higher WUE. Similar results are observed by Meena *et al*. (2016) [10].

Nitrogen level N_3 (50% RDN through chemical fertilizer + 50% RDN through vermicompost) recorded maximum AUE (24.49). The AUE is directly related with the yield of the crop and proper utilization of nutrients.

Non-Significant variation in EC, pH and organic carbon content, available phosphorus and potash content in soil after harvest was observed due to different levels of nitrogen management treatments.

Significant variation in available nitrogen content in soil after harvest was observed due to different levels of nitrogen management [Table-5]. Nitrogen level N_4 (100% RDN through vermicompost) recorded significantly the highest available nitrogen (188.21 kg/ha).

Data shown in [Table-6] indicated that the effect of nitrogen management on nitrogen content of groundnut seed was found to be non-significant. Nitrogen management had significant effect on nitrogen uptake by seed. Significantly the highest nitrogen uptake (57.24 kg/ha) by seed was noted with nitrogen level N_3 (50% RDN through chemical fertilizer + 50% RDN through vermicompost). Application of vermicompost to groundnut enhanced the nitrogen uptake by seed. It might due to the steady and increased availability of nutrients from vermicompost, which might have resulted in increased uptake of nutrients by plants. These results are in conformity with the work of Raju *et al*. (2013) [11] in safflower.

Table-9 Interaction of irrigation scheduling and nitrogen management through different sources on economics of groundnut

Treatment combination	Pod yield (kg/ha)	Haulm yield (kg/ha)	Total cost of cultivation (₹ /ha)	Gross return (₹/ha)	Net return (₹ /ha)	BCR
I_1N_0	2036	2737	35539	100752	65212	2.83
I_1N_1	2631	3379	36026	138308	102282	3.83
I_1N_2	2855	3914	38197	150578	112381	3.94
I_1N_3	3170	4387	40189	167274	127085	4.16
I_1N_4	2714	3535	44181	142770	98589	3.23
I_2N_0	2949	3983	37573	155416	117843	4.13
I_2N_1	2959	3853	38060	155656	117596	4.08
I_2N_2	3037	4116	40231	160082	119851	3.97
I_2N_3	3270	4371	42223	172242	130019	4.07
I_2N_4	2953	3943	46045	155536	109491	3.37
I_3N_0	2912	3879	39607	153358	113751	3.87
I_3N_1	2617	3796	40094	138442	98348	3.45
I_3N_2	3008	3868	42265	158136	115871	3.74
I_3N_3	3116	4130	44257	164060	119803	3.70
I_3N_4	2610	3632	48249	137764	89515	2.85
I_4N_0	2910	2626	31471	107274	75803	3.40
I_4N_1	2133	2837	31958	112324	80366	3.51
I_4N_2	2703	3606	34129	142362	108233	4.17
I_4N_3	2778	3762	36121	146424	110303	4.05
I_4N_4	2179	3104	40113	115158	75045	2.87

Data shown in [Table-6] indicated that the effect of nitrogen levels on nitrogen content of groundnut haulm was found to be non-significant. Nitrogen levels had significant effect on nitrogen uptake by haulm. Significantly the highest nitrogen uptake (129.78 kg/ha) by haulm was noted with nitrogen level N_3 (50% RDN through chemical fertilizer + 50% RDN through vermicompost). It might due to the steady and increased availability of nutrients from vermicompost, which might have resulted in increased uptake of nutrients by plants. The results are in conformity with the work of Raju *et al*. (2013) in safflower.

Interaction effect (I × N)

Interaction effect of irrigation and nitrogen management treatments on grain yield of groundnut was found significant [Table-4]. The treatment combination I_2N_3 (0.8 IW: CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost) recorded significantly higher pod yield (3270 kg/ha) and haulm yield (4371 kg/ha).This might be due to more vigorous crop growth and higher order of yield attributes under frequent irrigation with adequate supply of nutrient through vermicompost during crop period resulted in higher grain yield.

Significantly higher WUE was recorded under treatment combination I_4N_3 (9.26 kg ha/mm), which was remained at par with treatment combination I_4N_2 (9.01 kg/mm). The interaction effect between irrigation and nitrogen management with respect to EC, pH and organic carbon content, available nitrogen, phosphorus and potash in soil after harvest was found to be non-significant.

The interaction effect between irrigation and nitrogen management with respect to nitrogen content in seed and haulm of groundnut was found to be non-significant.

The significantly higher nitrogen uptake by seed (68.27 kg/ha) was recorded under treatment combination I_2N_3 (0.8 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost), however, this treatment combination was remained at par with the treatment combinations I_3N_3 (1.0 IW:CPE and 50% RDN through chemical fertilizer + 50% RDN through vermicompost), I_2N_2 (0.8 IW:CPE and 75% RDN through chemical fertilizer + 25% RDN through vermicompost), I_2N_1 (0.8 IW:CPE and 100% RDN through chemical fertilizer) and I_2N_4 (0.8 IW:CPE and 100% RDN through vermicompost.

Significantly higher nitrogen uptake by haulm (146.96 kg/ha) was recorded under treatment combination I_2N_3 (0.8 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost), however, this treatment combination was remained at par with the treatment combinations I_1N_3 (0.6 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost), I_2N_2 (0.8 IW:CPE and 75% RDN through chemical fertilizer + 25% RDN through vermicompost), I_3N_3 (1.0 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost) and I_2N_1 (0.8 IW:CPE and 100% RDN through chemical fertilizer).

The treatment combination I_2N_3 (0.8 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost) recorded higher net realization (₹ 130019) and it was followed by treatment combination I_1N_3 (0.6 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost). The BCR (4.16) registered higher with treatment combination I_1N_3 (0.6 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost) as compared to I_2N_3 (0.8 IW:CPE ratio and 50% RDN through chemical fertilizer + 50% RDN through vermicompost).

Conclusion

From the foregoing results, it is concluded that significantly higher pod yield, haulm yield, nitrogen content in seed and haulm, nitrogen uptake by seed and haulm and net realization of the groundnut should be irrigated at 0.8 IW: CPE ratio in conjunction with 50% RDN through chemical fertilizer + 50% RDN through vermicompost as a basal application.

Application of research

To know the Effect of irrigation scheduling and nitrogen sources on growth and yield of summer groundnut (*Arachis hypogaea* L).

Research Category: Agronomy

Abbreviations: WUE- water use efficiency, RDN - Recommend dose of nitrogen

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****Research Guide or Chairperson of research: Dr R. A. Patel**

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Research project name or number: MSc Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Agronomy farm, Anand Agriculture University, Anand

Cultivar / Variety / Breed name: Groundnut (*Arachis Hypogaea* L.) - Groundnut (GG-34)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
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