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Research Article

IRRIGATION SCHEDULING: CLIMATOLOGICAL APPROACH FOR GROWTH, YIELD AND ECONOMICS ON SUMMER GROUNDNUT (*ARACHIS HYPOGAEA*)

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Abstract: Field experiments were conducted to optimize the irrigation scheduling and nutrient management practices for groundnut (*Arachis hypogaea*) under irrigated condition during summer season of 2017 at Central Farm, Agricultural College and Research Institute, Madurai, Tamil Nadu. The experiments were laid out in split plot design. Bunch variety, VRI 2 was chosen for the experiments. Soil of the experiment field were sandy clay loam in texture with low available nitrogen and medium available phosphorus and high available potassium. The main plot treatments consisted of three levels of irrigation scheduling namely 0.8 IW/CPE ratio (I_1), 0.6 IW/CPE ratio (I_2) and 0.4 IW/CPE ratio (I_3) and four nutrient management practices in the sub-plots *i.e.* N_1- 75% RDF with 5 t of charred rice husk, N_2 - 50% RDF with 5 t of charred rice husk, N_3 - 75% RDF with 5 t of charred rice husk along with seed treatment of arbuscular mycorrhiza and N_4 - 50% RDF with 5 t of charred rice husk along with seed treatment arbuscular mycorrhiza. Among the irrigation scheduling and nutrient management practices, the growth parameters and pod yield were highest with the treatment combination of irrigation scheduling of 0.8 IW/CPE ratio along with 75% of RDF and 5 t of charred rice husk as basal with seed treatment of arbuscular mycorrhiza with a pod yield of 2003 kg/ha during summer' 2017 season. Whereas, the lowest pod yield was recorded with irrigation scheduling of 0.4 IW/CPE ratio with 75% of RDF and 5 t of charred rice husk. The net return per hectare and B:C ratio increased with increase in the level of irrigation. The highest net return and B:C ratio were recorded with irrigation scheduling of 0.8 IW/CPE ratio and application of 75% of RDF and 5 t of charred rice husk as basal along with seed treatment of arbuscular mycorrhiza during summer season.

Keywords: *Irrigation scheduling, summer season, groundnut crop, yield, water use efficiency and economics*

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Introduction

Groundnut is an important oil and protein source to a large portion of the population in India. It is an annual, herbaceous legume and considered as king of vegetable oil seed crops in India and occupies a pre-eminent position in national edible oil economy. Groundnut seed contain 47-53 percent oil, 26.0 percent protein and 11.5 percent starch. It is currently grown in an area of 53.34 million hectares over the India [1]. Irrigation water, a crucial input in crop production is scarce and expensive. Efficient use of this input is essential which can be achieved through judicious water management practices. Adequate and timely supply of water is essential for higher yields. Keeping the total quantity of irrigation water constant, increasing the frequency of irrigation would maximize the yield in groundnut [2]. Groundnut is grown during *kharif*, *rabi* and summer seasons in India. Groundnut has specific moisture needs due to its peculiar feature of producing pods underground. In groundnut early moisture stress restricts the vegetative growth which in turn reduces the yield and at the peak flowering and pegging period is most sensitive as the peg cannot penetrate through dry and hard surface. The summer crop avails the residual moisture and the scanty rainfall and produces substantial yield few supplementary irrigations would improve the yield. This approach integrates all the weather parameters that determine water use by the crop and is likely to increase production at least 15-20%.

Optimum scheduling of irrigation led to increase in pod and haulm yield [3]. To ensure increased yield in summer season in traditional areas of Tamil Nadu it is necessary to have a thorough understanding of the changes in the soil-plant-water relations and various morpho-physiological processes in relation to scheduling of irrigation water.

Materials and Methods

Field experiments were conducted in D block at the Central farm, Department of Farm Management, Agriculture College and Research Institute, Madurai, Tamil Nadu. The soil is slightly alkaline (pH >7.5), sandy loam with low organic carbon content (0.46 percent). The treatments consisted of three irrigation scheduling with 0.8 IW/CPE (I_1), 0.6 IW/CPE (I_2) and 0.4 IW/CPE (I_3) and fertilizer treatments *viz.* N_1- 75 RDF+ 5 t of charred rice husk, N_2- 50 RDF+ 5 t of charred rice husk, N_3- 75 RDF+ 5 t of charred rice husk along arbuscular mycorrhiza and N_4- 75 RDF + 5 t of charred rice husk along arbuscular mycorrhiza. The recommended fertilizer was applied through basal along. N was supplied through urea, P_2O_5 through SSP and K_2O through muriate of potash. VRI-2 variety of groundnut was sown in third week of February 2017. The crop was harvested on 2 June 2017. Irrigation schedules were followed based on the IW/CPE based (Climatological approach). The amount of water irrigated is given separately.

Table-1 *Effect of irrigation scheduling and nutrient management practices on plant height (cm) of groundnut during summer' 2017*

Treatment	25 DAS				50 DAS				75 DAS				At Harvest			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	12.27	12.26	12.28	12.27	22.56	22.67	17.12	20.78	41.92	40.57	34.69	39.06	47.89	46.56	42.46	45.60
N_2	12.23	12.25	12.01	12.16	22.73	22.59	16.63	20.65	41.33	40.33	33.93	38.53	47.70	45.22	42.13	45.07
N_3	12.37	12.72	12.47	12.52	25.92	24.59	18.27	22.93	46.08	45.55	38.18	43.27	50.06	49.46	45.22	48.25
N_4	12.65	12.07	12.17	12.30	23.47	22.41	19.65	21.85	42.68	43.61	`39.77	42.02	48.91	47.89	45.78	47.53
Mean	12.38	12.33	12.23		23.67	23.06	17.92		43.00	42.51	36.64		48.66	47.28	43.90	
	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I
SEd	0.352	0.567	0.802	0.802	0.568	0.559	0.790	0.790	0.551	0.770	1.089	1.089	1.285	1.165	1.648	1.648
CD (p=0.05)	NS	NS	NS	NS	1.336	1.191	1.536	1.536	1.296	1.641	2.116	2.116	3.024	2.484	3.202	3.202

Table-2 *Effect of irrigation scheduling and nutrient management practices on leaf area index of groundnut during summer' 2017*

Treatment	25 DAS				50 DAS				75 DAS				At Harvest			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	1.13	1.14	1.09	1.12	2.72	2.60	2.27	2.53	4.10	3.98	3.47	3.85	3.79	3.84	3.31	3.65
N_2	1.12	1.10	1.08	1.10	2.69	2.59	2.26	2.51	4.01	3.75	3.42	3.73	3.67	3.60	3.28	3.52
N_3	1.18	1.17	1.15	1.17	3.00	2.90	2.51	2.80	4.39	4.26	3.76	4.14	4.12	4.03	3.52	3.89
N_4	1.14	1.18	1.13	1.16	2.83	2.72	2.53	2.69	4.23	4.19	3.73	4.05	3.99	3.73	3.46	3.73
Mean	1.16	1.15	1.11		2.81	2.70	2.39		4.18	4.05	3.60		3.89	3.80	3.39	
	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I
SEd	0.049	0.055	0.078	0.078	0.042	0.110	0.155	0.155	0.094	0.119	0.169	0.169	0.124	0.158	0.224	0.224
CD (p=0.05)	NS	NS	NS	NS	0.100	0.234	NS	NS	0.221	0.254	NS	NS	0.291	0.338	NS	NS

Table-3 *Effect of irrigation scheduling and nutrient management practices on dry matter production (kg ha-1) of groundnut during summer' 2017*

Treatment	25 DAS				50 DAS				75 DAS				At Harvest			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	787	753	778	773	1858	1753	1626	1745	3907	3783	3279	3656	4966	4654	3984	4534
N_2	789	779	764	777	1824	1748	1604	1725	3810	3762	3314	3628	4978	4735	3926	4546
N_3	800	798	776	791	2109	2068	1668	1948	4161	4176	3589	3975	5323	5276	4397	4998
N_4	798	794	754	782	2023	2001	1652	1892	4126	4037	3534	3899	5145	5036	4371	4850
Mean	793	781	768		1953	1892	1637		4001	3939	3429		5103	4925	4169	
	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I
SEd	10.84	12.32	17.43	17.43	42.14	32.46	45.91	45.91	65.85	70.20	99.27	99.27	46.85	55.83	78.95	78.95
CD (p=0.05)	NS	NS	NS	NS	99.18	69.21	89.22	89.22	154.99	149.66	192.91	192.91	110.271	119.025	153.427	153.427
RDF	688				1792				3545				4163			

Table-4 *Effect of irrigation scheduling and nutrient management practices on total number of pods/plant, 100 pod weight, 100 kernel weight and shelling percentage of summer groundnut 2017*

Treatment	Total number of pods/plant				100 pod weight				100 kernel weight				Shelling percentage			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	6	7	6	6	71	71	63	68	43	42	39	41	60	61	64	61
N_2	7	7	6	7	71	71	63	68	42	40	38	40	57	58	61	59
N_3	8	8	6	7	74	73	65	71	42	46	40	43	63	57	60	60
N_4	7	6	6	6	73	72	64	70	44	42	40	42	58	60	61	60
Mean	7	7	6		72	72	64		43	43	39		60	59	61	
	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I
SEd	0.068	0.117	0.166	0.166	1.060	0.981	1.388	1.388	0.668	1.424	2.014	2.014	-	-	-	-
CD (p=0.05)	0.161	0.250	0.322	0.322	2.494	NS	NS	NS	1.574	3.037	NS	NS	-	-	-	-
CRH	5				71				37				52			
RDF	6				73				40				56			
Control	4				62				33				57			

Table-5 *Effect of irrigation scheduling and nutrient management practices on pod yield, haulm yield and harvest index of summer groundnut 2017*

Treatment	Pod yield (kg ha^{-1})				Haulm yield (kg ha^{-1})				Harvest Index			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	1830	1646	1275	1584	4715	4718	4120	4518	0.40	0.30	0.30	0.33
N_2	1726	1693	1236	1552	4726	4638	4179	4514	0.41	0.38	0.30	0.34
N_3	2003	1978	1370	1784	4984	4948	4340	4757	0.39	0.38	0.30	0.36
N_4	1918	1886	1433	1746	4888	4736	4447	4690	0.40	0.36	0.30	0.35
Mean	1869	1801	1329		4828	4760	4271		0.40	0.37	0.30	
	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N	N X I
SEd	49.863	50.824	71.875	71.875	76.425	58.182	82.282	82.282				
CD (p=0.05)	117.349	108.351	139.668	139.668	179.859	124.039	159.891	159.891				
RDF	1370				4108				0.31			
Control	980				3782				0.26			

Table-6 *Effect of irrigation scheduling and nutrient management practices on economics of summer groundnut 2017*

Treatment	Gross Return (₹ ha^{-1})				Net Return (₹ ha^{-1})				B:C ratio		
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3
N_1	106420	96674	73866	92320	52620	43124	24366	40037	2.0	1.8	1.4
N_2	100930	99005	75815	91917	50830	49155	22615	40867	2.0	2.0	1.5
N_3	116127	114730	81290	104049	62127	60980	27890	50332	2.2	2.2	1.5
N_4	101430	109430	84843	98568	60130	59380	35143	51551	2.1	2.1	1.7
Mean	106227	104960	78954		56427	53160	27504		2.1	2.0	1.5
	I	N	I X N	N X I	I	N	I X N	N X I	I	N	I X N

$$I_1 \frac{IW}{CPE} = 0.8, CPE\ Ratio = 62.50\ mm$$

$$I_2 \frac{IW}{CPE} = 0.6, CPE\ Ratio = 83.33\ mm$$

$$I_3 \frac{IW}{CPE} = 0.4, CPE\ Ratio = 125.00\ mm$$

Leaf area index was computed using following formula

$$LAI = \frac{L \times W \times K \times Number\ of\ Leaves\ /\ Plant}{Spacing\ adopted\ (cm)}$$

The shelling percentage was ascertained for each plot.

Shelling Percentage=Kernel Weight/ Pod Weight X 100

For working out the economics, prevailing market prices for pod yield (4500/quintal), haulm yield (200/quintal), urea (8/kg N), SSP (18/kg P) and MOP (9/kg K). The data were statistically analyzed and the pooled results are presented.

Results and Discussion

Growth parameters

Plant height

Plant height was influenced by irrigation scheduling and nutrient management practices except at 25 DAS where it did not show any had significant effect among the treatments [Table-1]. Irrigation scheduling and nutrient management practices was found significant at 50, 75 DAS and at harvest stage. The treatment combination of 0.8 IW/CPE ratio with 75% of RDF and 5 t of charred rice husk along with seed treatment of arbuscular mycorrhiza (I_1N_3) registered the taller plants. Whilst, shortest plant height was recorded with treatment combination of 0.4 IW/CPE ratio along with 50% of RDF and 5 t of charred rice husk (I_3N_2) in summer season of experimentation.

Leaf area index

At 50, 75 DAS and at harvest stages significantly higher leaf area index of 2.81, 4.18 and 3.89 were observed with treatment of irrigation scheduling at 0.8 IW/CPE ratio (I_1) during summer' 2017 [Table-2]. The lowest leaf area index was recorded with irrigation scheduling of 0.4 IW/CPE ratio (I_3) treatment with value of 2.39, 3.60 and 3.39 at 50, 75 DAS and at harvest stage during summer' 2017 season. The nutrient management practices also significantly influenced the leaf area index at all stages of crop growth except 25 DAS. During summer' 2017, higher leaf area index values of 2.80, 4.14 and 3.89 were observed with application of 75% of RDF conjugated with 5 t of charred rice husk along seed treatment with arbuscular mycorrhiza (N_3) at 50, 75 DAS and at harvest stage respectively. Interactions between irrigation scheduling and nutrient management practices were not significant on leaf area index.

Dry matter production [Table-3]

Among the irrigation scheduling and nutrient management practices at 50, 75 DAS and harvest stage, the treatment combination of irrigation scheduling 0.8 IW/CPE ratio and nutrient management practices application of 75% RDF and 5 t of charred rice husk with seed treatment of arbuscular mycorrhiza (I_1N_3) recorded the highest dry matter production of 2109, 4161 and 5323 kg/ha during summer' 2017. Whereas, the lower dry matter production (1604, 3314 and 3926 kg/ha during summer' 2017 season at 50, 75 DAS and at harvest respectively) were recorded with irrigation scheduling at 0.4 IW/CPE ratio and 50% of RDF along with 5 t charred rice husk (I_3N_2).

Yield attributes

The yield attributes of groundnut were significantly influenced with irrigation scheduling and nutrient management practices [Table-4]. The treatment of 0.8 IW/CPE + 75 % RDF + 5 tons charred rice husk along arbuscular mycorrhiza (I_1N_3) gave more number of pods/plant, shelling percentage, 100 pod weight and 100 kernel weight compared with treatment of 0.4 IW/CPE + 75 % RDF + 5 tons charred rice husk (I_3N_2). This might be due to increase in number of irrigations applied at shorter intervals and total consumptive use of water. These situations avoided soil moisture stress and thus, provided very favourable conditions for soil moisture and nutrients availability to the plants and ultimately higher yield attributes. The lower number of pods per plant might be due to limited water supply, which provided the inherent inability under low soil moisture conditions. It might be due to attributed to higher biomass accumulation coupled with effective translocation and distribution of photosynthesis from source to sink, which in turn resulted into elevated stature of yield attributes. The results are in close conformity with findings [4].

Yield of groundnut crop

The data pertaining in [Table-5] to effect of irrigation scheduling and nutrient management practices was significant for pod yield and haulm yield. Significantly the highest pod yield was recorded under treatment of 0.8 IW/CPE + 75 % RDF + 5 t of charred rice husk along AM (I_1N_3), followed by treatment of 0.6 IW/CPE + 75 % RDF + 5 t of charred rice husk along arbuscular mycorrhiza (I_2N_3), whereas, significantly lower pod yield was observed under treatment of 0.4 IW/CPE + 50 % RDF + 5 t of charred rice husk (I_3N_2),. The treatment of 0.8 IW/CPE + 75 % RDF + 5 t of charred rice husk along arbuscular mycorrhiza (I_1N_3), recorded higher pod yield, that increase at the extent of 46% over the treatments of 0.4 IW/CPE + 50 % RDF + 5 t of charred rice husk during summer 2017 season. The increase in pod yield might be due to increase in irrigation frequency and consumptive use because of increased ratio. Thus, there was progressive increase in pod yield due to favourable soil moisture condition and better availability of soil moisture at higher frequency of irrigation throughout the crop growth period, which remarkably stimulated yield attributes and finally pod yield. Other reason might be due to increase in numbers of irrigation applied at shorter intervals and total consumptive use of water; the improving pod yield is higher level of available soil moisture during cropping season that directly focuses on pod yield. Patra and Singh (2012) reported higher pod and haulm yields with application of fertilizer application. Ground nut crop under irrigation scheduling *viz*., 0.6, 1.0 and 0.8 IW/CPE ratio resulted in higher yield of dry pods, haulm and kernel respectively [5].

Economics

With an increased in irrigation frequency, the total expense on cultivation increases accordingly [Table-6] *viz*., 0.8 IW/CPE + 75% RDF + 5 tons charred rice husk along arbuscular mycorrhiza (I_1N_3), 0.6 IW/CPE + 75% RDF + 5 t of charred rice husk along arbuscular mycorrhiza (I_2N_3) and 0.4 IW/CPE + 75% RDF + 5 t of charred rice husk (I_3N_2). Gross return, net return per hectare and B:C ratio increased with increase in the level of irrigation. The results indicated that net returns were comparatively higher in 0.8 IW/CPE + 75% RDF + 5 t of charred rice husk along AM (I_1N_3) value of ₹62,127 which was followed by 0.6 IW/CPE + 75% RDF + 5 t of charred rice husk along arbuscular mycorrhiza (I_2N_3) value of ₹60,980 and this was due to higher yield obtained in these treatments. Whereas, the net returns were minimum in ₹22,615 in 0.4 IW/CPE + 75% RDF + 5 tons charred rice husk (I_3N_2). This finding was in conformity with [6] and [7] have also reported higher net income and benefit cost ratio through application of irrigation scheduling and organic amendment of charred rice husk conjugation with arbuscular mycorrhiza. The maximum gross return, net return and B:C ratio was recorded at irrigation level 0.8 IW/CPE ratio (I1) and it was minimum under irrigation scheduled at 0.4 IW/CPE ratio I_3). Higher gross return, net return and B:C ratio at higher frequency of irrigation was due to higher yield. The net profit was relatively higher because of the magnitude of increase in yield.

Conclusion

In irrigation scheduling and nutrient management practices with treatment of 0.8 IW/CPE in conjunction with an application of + 75% RDF + 5 t of charred rice husk with arbuscular mycorrhiza (I_1N_3) was proved to be the best considering the growth, yield and economics. Thus, cultivation of groundnut crop under irrigated condition during summer season by adopting 0.8 IW/CPE + 75% RDF + 5 t of charred rice husk along arbuscular mycorrhiza (I_1N_3) is profitable.

Application of research: The study provides information that groundnut crop responds very well to irrigation scheduling and nutrient management with charred rice husk along arbuscular mycorrhiza.

Research Category: Irrigation Management

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Study area / Sample Collection: D Block, Central farm, Department of Farm Management, Agriculture College and Research Institute, Madurai, Tamil Nadu

Cultivar / Variety name: Groundnut (*Arachis hypogaea*)

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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