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Green and Blue Water Footprint for Groundnut (*Arachis hypogaea* L.) under Irrigation Scheduling and Nutrient Management Practices

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ABSTRACT

Background: Water shortage is a key obstacle to the sustainable supply of food to the world and Indian population, since largest consumptive water use. This research paper determines he water footprint of green and blue water for groundnut under an irrigated conditions during different seasons.

Methods: The field experiments were conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu during summer*, kharif* and *rabi* 2016-2018. The experiments were laid out in a split-plot design with three replications. The main plot consisted of three levels of irrigation scheduling namely 0.8, 0.6 and 0.4 IW/CPE ratios and sub-plots comprised of four nutrient management practices *viz.,* 75% of RDF with 5 tones/ha of charred rice husk, 50% of RDF with 5 tones/ha of charred rice husk, 75% of RDF with 5 tones/ha of charred rice husk along with seed treatment of *Arbuscular mycorrhiza* and 50% of RDF with 5 tones/ha of charred rice husk along with seed treatment *Arbuscular mycorrhiza*.

Result: The study revealed that the growth attributes, pod yield and haulm yield, rain and irrigation water content and water use studies of groundnut were registered higher with irrigation scheduling at 0.8 IW/CPE ratios along with the application of 75% RDF and 5 tones/ha of charred rice husk as basal with seed treatment of *Arbuscular mycorrhiza.* The higher green water content has been recorded with irrigation scheduling at 0.6 and 0.4 IW/CPE ratios during summer' and *kharif'* 2017. The higher blue water content was recorded under irrigation scheduling at 0.8 IW/CPE ratios during all three seasons.

Key words: Groundnut, Irrigation scheduling, Nutrient management practices, Yield attributes.

INTRODUCTION

Groundnut is one of the most important oilseed crops among the oilseeds. India ranks first in the area and third in productivity next to the USA and China. Hence, the availability of water and nutrients is the main factor, which has that determines the productivity of the groundnut specially during flowering and peg formation stage (Balasubramanian *et al.,* 2020). Agriculture stands as the largest consumptive water user worldwide: it needs massive amounts of water to produce agricultural products (Hoekstra *et al.,* 2011), based on the studies of virtual water performed laid out the concept of water footprint. This term is defined as the total volume of freshwater used during the production and consumption of goods and services, measured at the place, where the product was produced (Chapagain and Hoekstra, 2008). Water consumptive use is measured in terms of the water volume consumed and evaporated per unit of time. Water foot has been split into three components as green, blue and grey water. Green water the portion of rainfall that is stored as moisture in the soil (Falkenmark and Rockstrom, 2006) and blue water (surface and groundwater) refer to consumption/evapotranspiration during the production of a good.

In Madurai, Tamil Nadu, the groundnut crop is mainly produced under irrigated conditions. The region produces about 65% of groundnut production; this fact leads farmers to look for the best conditions that rainfall could provide. The geographical location of this zone provokes that potential evapotranspiration is higher than precipitation. Therefore, crop yield is almost always lower than potential. This research article sets out to characterize the green and blue water of groundnut crop produced in the respective region.

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Materials and Methods

Field experiments were conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu on groundnut during summer, *kharif* and *rabi* seasons for the year 2016-2018. The average meteorological weather conditions, total rainfall was 129.0, 372.8 and 16.6 mm, average temperature range of 23.4 and 37.8°C and the daily pan evaporation was 6.2 mm during summer, *kharif* and *rabi* 2017 in the crop growing period. The soil was sandy loam in texture, which belongs to vylogam series. The experiments were laid out in a split-plot design with three replications. The main plots consisted of three levels of irrigation scheduling as I_1- 0.8, I_2- 0.6 and I_3- 0.6 IW/CPE ratio and subplots comprised of four levels of nutrient management namely N_1 - 75% of RDF + 5 tones/ha of charred rice husk, N_2 - 50% of RDF + 5 tones/ha of charred rice husk, N_3 - 75% of RDF + 5 tones/ha of charred rice husk with seed treatment of *Arbuscular mycorrhiza* and N_4 - 50% of RDF + 5 tones/ha of charred rice husk with seed treatment of *Arbuscular mycorrhiza*. A short duration (100-110 days) bunch variety of groundnut VRI-2 was used as a test variety. Scheduling of irrigation was computed using the evaporation data observed from the Agromet observatory at AC and RI, Madurai. Triple channel layout was adopted for main plot treatments to eliminate the effect of lateral seepage. For one irrigation, 50 mm of water was applied using parshall flume. Soil amendment *i.e.,* charred rice husk was applied at 5 tones/ha (moisture-free) incorporated well in the field before sowing of crops. The green and blue water can be calculated as follows (Falkenmark and Rockström., 2004):

$$CWU_{green} = 10 \times \sum_{D=1}^{lgp} ET_{green}$$

$$CWU_{blue} = 10 \times \sum_{D=1}^{lgp} ET_{blue}$$

The green and blue footprint in crop water use (m^{-3} ha^{-1}) were calculated by the accumulation of daily evaporation (mmday^{-1}) over the complete growing period in which ET green represents green water evapotranspiration and ET blue represents blue water evapotranspiration. Factor 10 is mean to convert water depths in mm into volume per land surface in m^{-3} ha^{-1}. The summation is done over the period from the day of planting (day 1) to the day of harvest (lgp stands for the length of the growing period in days). Growth parameters like plant height, dry matter production and pod and haulm yield were recorded and the experimental data collected were subjected for statistical analysis as suggested by Gomez and Gomez (1984).

Results and Discussion

Number of irrigations applied as per irrigation scheduling

Within the treatments, irrigation scheduling at 0.8 IW/CPE ratio requires more water (400 mm) with a total of eight irrigation during summer 2017. Whereas, scheduling of irrigation at 0.6 and 0.4 IW/CPE ratio each required five irrigations of 250 mm. During *kharif* 2017, 0.4 and 0.8 IW/CPE irrigation schedule with 100 and 200 mm of water with two and four irrigations were applied, respectively. In the crop of *rabi'* 2017, scheduling of irrigation at 0.8 IW/CPE ratio required 450 mm, whereas, with 0.6 IW/CPE applied 350 mm and 0.4 IW/CPE used 250 mm during the crop season and the data are presented in Table 1.

Growth attributes

Plant height and dry matter production were influenced by irrigation scheduling and nutrient management practices (Table 2). The significantly taller plants of 52.79, 51.21 and 50.06 cm and dry matter production of 5328, 5076 and 5323 kg ha^{-1} at harvest during *kharif, rabi* and summer, respectively were observed with irrigation scheduling of 0.8 and 0.6 IW/CPE each with 75 and % RDF + 5 tones/ha of charred rice husk along with seed treatment of *Arbuscular mycorrhiza* and which was comparable with each other. The increased soil moisture availability to the crop might have provided optimum moisture supply and uptake by the crop resulting in increased cell division, stem elongation and finally increased plant height and dry matter production. Further, conjugation of *Arbuscular mycorrhiza* could have paved to create more adsorptive surface for the uptake of nutrients by the crop. Earlier work of Ahlawat and Gangaiah (2010) collaborate with the above results. The lower plant height was observed with irrigation scheduling at 0.4 IW/CPE which was due to the decreased soil moisture availability has resulted in stunted growth, probably with decreased absorption of water, leading to poor growth during all the seasons. Similar work has been reported by Hassan *et al.* (2016).

Pod and haulm yield

Irrigation scheduling and nutrient management practices also significantly influenced the pod yield, irrigation scheduling at 0.8 IW/CPE ratio with 75% RDF + 5 tones/ha of charred rice husk along with seed treatment of *Arbuscular mycorrhiza* recorded the higher pod yield and haulm yield of 2099 and 5062 kg ha^{-1}, 2063 and 5083 kg ha^{-1} and 2003 and 4984 kg ha^{-1} respectively (Table 3). This was comparable with irrigation scheduling of 0.6 IW/CPE ratio with 75% RDF + 5 tones/ha of charred rice husk along with seed treatment of *Arbuscular mycorrhiza*. This could due to the incorporation of rice husk as basal That increased the water and nutrients availability for longer period and enhanced the yield. The lower pod yield of 1288, 1206 and 1236 kg ha^{-1} and haulm yield of 3768, 4016 and 4023 during *kharif, rabi* and summer, respectively. The presence of growth-promoting substances due to colonization of *Arbuscular mycorrhiza* promoted plant growth and could have increased chlorophyll production by boosting the photosynthetic process and stimulating vegetative growth. Thus, an overall plant performance would have enhanced and finally reflecting through increased production of haulm were observed with irrigation scheduling

Table 1: Number of irrigations applied as per the irrigation scheduling during summer*, kharif and rabi'* 2017.

Number of irrigations	0.8 IW/CPE	Days after previous irrigation	0.6 IW/CPE	Days after previous irrigation	0.4 IW/CPE	Days after previous irrigation
Summer season						
Sowing irrigation	16.02.2017	-	16.02.2017	-	16.02.2017	-
Lifesaving irrigation	19.02.2017	3	19.02.2017	3	19.02.2017	3
First irrigation	09.03.2017	18	26.03.2017	35	01.04.2017	41
Second irrigation	24.03.2017	15	10.04.2017	16	22.04.2017	21
Third irrigation	07.04.2017	11	25.04.2017	15	14.05.2017	22
Fourth irrigation	18.04.2017	11	-	-	-	
Fifth irrigation	29.04.2017	11	-		-	
Sixth irrigation	10.05.2017	11	-		-	
Number of irrigations	08		05		05	
Total water used	400 mm		250 mm		250 mm	
Kharif **season**						
Sowing irrigation	06.09.2017	-	06.09.2017	-	06.09.2017	-
Lifesaving irrigation	09.09.2017	3	09.09.2017	3	09.09.2017	3
First irrigation	18.11.2017	70	21.11.2017	74	17.12.2017	99
Second irrigation	18.12.2017	30	-	-	-	-
Number of irrigations	04		03		02	
Total water used	200 mm		150 mm		100 mm	
Rabi **season**						
Sowing irrigation	21.12.2017	-	21.12.2017	-	21.12.2017	-
Lifesaving irrigation	24.12.2017	3	24.12.2017	3	24.12.2017	3
First irrigation	12.01.2018	19	17.01.2018	24	27.01.2018	34
Second irrigation	28.01.2018	16	04.02.2018	18	23.02.2018	27
Third irrigation	11.02.2018	14	24.02.2018	20	22.03.2018	27
Fourth irrigation	24.02.2018	13	11.03.2018	15	-	-
Fifth irrigation	07.03.2018	11	31.03.2018	20	-	-
Sixth irrigation	23.03.2018	16	-	-	-	-
Seventh irrigation	04.04.2018	12	-	-	-	-
Number of irrigations	09		07		05	
Total water used	450 mm		350 mm		250 mm	

*One irrigation required 50 mm of irrigation water.

at 0.4 IW/CPE ratio with 50% RDF + 5 tones/ha of charred rice husk during all the seasons. The results were in similarity to the findings of Gouda *et al.* (2018).

Green and blue water

The green and blue water, were calculated from the volume of water used in different irrigation scheduling during summer, *kharif* and *rabi* seasons are presented in Table 4. Among the different treatments, 0.6 IW/CPE ratio recorded higher green water of 1320 m^{-3} ha^{-1} during summer. The lowest green water was recorded with 0.8 IW/CPE ratio with a value of 740 m^{-3} ha^{-1}. During *kharif* season, at 0.4 IW/CPE ratio was recorded highest green water with the value of 3106 m^{-3} ha^{-1}. Among the irrigation scheduling, 0.8 IW/CPE ratio recorded the lowest green water with a value of 2408 m^{-3} ha^{-1}. Irrigation scheduling of 0.8 IW/CPE ratio was showed more blue water with a value of 4000, 2000 and 4500 m^{-3} ha^{-1} during summer, *kharif* and *rabi* season, respectively. Whereas, the lowest blue water was observed with 0.4 IW/CPE ratio in summer, *kharif* and *rabi* season. Comparing these results with those obtained in this study, it was found some similarity in the green water footprints by Mekonnen and Hoekstra, (2010).

Water use efficiency

As regards to water use efficiency, the highest water use efficiency was registered with 0.8 IW/CPE ratio and application of 75% of RDF with 5tones/ha charred rice husk along with seed treatment of *Abuscular mycorrhiza* with a value of 4.35, 7.37, 5.27. Invariably in all the seasons, irrigation scheduling of 0.4 IW/CPE ratio with an application of 50% of RDF and 5 tones/ha charred rice husk registered the lowest water use efficiency and the data are furnished in Table 5. Hence, it can be very well stated that the application of charred rice husk improved the water retention in the soil as compared to control. Earlier studies by Karam *et al.* (2009) had shown that the application of charred rice husk resulted in a reduction of water through evaporation due

Table 2: Effect of irrigation scheduling and nutrient management practices on plant height (cm) and dry matter production (kg ha^{-1}) of groundnut at harvest during *kharif, rabi* and summer' 2017.

Treat-	Plant height												Dry matter production											
ment	*Kharif*				*Rabi*				Summer				*Kharif*				*Rabi*				Summer			
	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	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N	48.58	47.60	40.53	45.57	44.74	43.70	37.83	42.12	47.89	46.56	42.46	45.60	4962	4663	4250	4625	4750	4554	4119	4750	4966	4654	3984	4534
N,	41.52	40.28	39.80	40.53	44.65	41.81	36.42	40.91	47.70	45.22	42.13	45.07	4904	4530	4153	4529	4588	4389	4005	4588	4978	4735	3926	4546
Nƒ	52.79	51.43	43.57	49.26	51.21	46.05	42.61	46.32	50.06	49.46	45.22	48.25	5328	5275	4486	5030	5076	4981	4359	5076	5323	5276	4397	4998
N„	47.90	48.15	42.50	46.18	47.62	47.86	39.43	44.80	48.91	47.89	45.78	47.53	5120	5068	4428	4872	4992	4728	4295	4992	5145	5036	4371	4850
Mean	47.70	46.86	41.60		47.03	44.83	38.62		48.66	47.28	43.90		5079	4884	4329		4851	4663	4194	4851	5103	4925	4169	
	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	I	I	N	I × N	N × I
CD (p=0.05)	1.84	1.50	1.93	1.93	1.90	1.54	1.99	1.99	3.02	2.48	3.20	3.20	250	201	259	259	208	184	237	208	110	119	153	153

Table 3: Effect of irrigation scheduling and nutrient management practices on pod yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) of groundnut during *kharif, rabi* and summer' 2017.

Treat-	Pod yield												Haulm yield											
ment	*Kharif*				*Rabi*				Summer				*Kharif*				*Rabi*				Summer			
	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	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N	1978	1845	1329	1717	1810	1662	1251	1574	1830	1693	1275	1599	4760	4471	3897	4376	4658	4208	4132	4333	4726	4616	4155	4499
N,	1871	1766	1288	1641	1749	1644	1206	1553	1726	1646	1236	1536	4606	4384	3768	4253	4548	4489	4016	4351	4715	4538	4023	4425
Nƒ	2099	2022	1685	1935	2063	2001	1498	1854	2003	1978	1365	1783	5062	5004	4272	4779	5083	4950	4338	4790	4984	4846	4401	4743
N„	2075	2004	1623	1901	1937	1857	1415	1736	1918	1886	1433	1745	4936	4863	4215	4671	4950	4770	4128	4616	4888	4809	4330	4675
Mean	2005	1909	1481		1890	1791	1357		1869	1800	1328		4841	4681	4038		4810	4604	4153		4828	4702	4227	
	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	N × I	I	N	I × N	N × I
CD (p=0.05)	75	95	122	122	94	99	128	128	117	108	140	140	170	172	222	222	2386	186	239	239	180	124	160	160
RDF		1598				1478				1470												4205	4214	4380

Table 4: Estimation of green and blue water for groundnut crop during summer, *kharif* and *rabi* 2017.

Irrigation scheduling	Summer		*Kharif*		*Rabi*	
	Green water (m^{-3} ha^{-1})	Blue water (m^{-3} ha^{-1})	Green water (m^{-3} ha^{-1})	Blue water (m^{-3} ha^{-1})	Green water (m^{-3} ha^{-1})	Blue water (m^{-3} ha^{-1})
0.8 IW/CPE	1220	4000	2408	2000	158	4500
0.6 IW/CPE	1320	2500	3071	2000	136	3500
0.4 IW/CPE	952	2500	3106	1000	158	2500

Data not statistically analyzed.

Table 5: Effect of irrigation scheduling and nutrient management practices on water use efficiency (kg $ha^{-1}mm^{-1}$) and water productivity (₹ m^{-3}) of groundnut during summer, *kharif* and *rabi'* 2017.

Treat-	Summer								*Kharif*								*Rabi*							
	Water use efficiency				Water productivity				Water use efficiency				Water productivity				Water use efficiency				Water productivity			
ment	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	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N	3.97	3.68	2.77	3.57	251.43	240.48	207.60	221.17	6.95	6.48	4.67	6.06	248.16	214.73	201.45	221.45	4.63	4.25	3.24	4.04	219.62	254.66	274.16	249.70
N,	3.75	3.57	2.68	3.36	202.26	246.28	204.31	217.62	6.57	6.20	4.52	5.83	247.12	223.88	188.58	219.86	4.47	4.20	3.20	4.02	217.29	266.54	270.88	251.35
Nƒ	4.35	4.30	2.96	3.94	235.07	285.40	222.59	247.69	7.37	7.10	5.92	6.83	274.75	256.71	227.07	252.84	5.27	5.11	3.83	4.74	242.40	302.63	312.54	285.85
N„	4.17	4.10	3.11	3.83	205.32	272.21	232.32	236.62	7.29	7.04	5.70	6.74	259.26	247.34	219.69	242.10	4.95	4.75	3.62	4.44	231.70	277.92	313.60	274.41
Mean	4.16	3.94	2.96		214.03	261.09	216.62		7.07	6.73	5.23		257.32	235.67	209.20		4.86	4.63	3.52		227.83	275.44	292.59	

Data not statistically analyzed.

to improvement in soil physical properties such as increased soil aggregations and improved water holding capacity.

Water productivity

The data on water productivity are furnished in Table 5. Irrigation scheduling of 0.6 IW/CPE ratio with an application of 75% of RDF along with the application of 5 tones/ha charred rice husk registered the higher water productivity of ₹ 285.40 and ₹ 256.71 m^{-3} during summer and *kharif* season, respectively. Whereas, irrigation scheduling of 0.8 IW/CPE ratio and application of 50% of RDF with 5 tones/ha charred rice husk recorded the lower value of ₹ 202.26 and ₹ 217.29 during summer and *rabi* season, respectively. Similar results were observed by Prajapati *et al.* (2007).

Conflict of interest: None.

REFERENCES

Ahlawat, I.P.S. and Gangaiah, B. (2010). Response of Bt cotton (*Gossypium hirsutum*) hybrids to irrigation. Indian Journal of Agricultural Science. 80(4): 271-274.

Balasubramanian, P. Nethaji Mariappan, V.E., Keisar Lourdusamy, D., Chinnamuthu, C.R. and Swetha, S. (2020). Peanut as a smart food and their nutrients aspects in planet: A review. Agricultural Reviews. 41(4): 403-407.

Chapagain, A.K. and Hoekstra, A.Y. (2008). The global component of freshwater demand and supply: An assessment of virtual water flows between nations as a result of trade in agricultural and industrial products. Water Int. 33: 19-32.

Falkenmark, M. and Rockströ, J. (2004). Balancing Water for Man and Nature: The New Approach to Ecohydrology. Earth Scan. U.K.

Falkenmark, M. and Rockstrom, J. (2006). The new blue and green water paradigm: Breaking new ground for water resources planning and management. J. Water Resour. Plan. Manag. 132: 129-132.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. New Delhi, India. John Wiley. 680p.

Gouda, S., Kerry, R.G., Samal, D., Mahapatra, G.P., Das, G. and Patra, J.K. (2018). Application of Plant Growth Promoting Rhizobacteria in Agriculture. Advances in Microbial Biotechnology Current Trends and Future Prospects. Edition: pp. 73-83.

Hassan, S.F., Shadha, A.A., Layla, I.M. and Musaab, A.Y. (2016). Response of cotton to potassium levels under water regime. International Journal of Applied Agricultural Science. 2(4): 56-63.

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M. and Mekonnen, M.M. (2011). The Water Footprint Assessment Manual: Setting the Global Standard. Earthscan. London, UK.

Karam, F., Masaad, R., Bachour, R. Rhayem, C. and Rouphael, Y. (2009). Water and radiation use efficiencies in drip-irrigated pepper (*Capsicum annuum* L): Response to full and deficit irrigation regimes. European Journal of Horticultural Science. 74(2): 79-85.

Mekonnen, M.M. and Hoekstra, A.Y. (2010). A global and high-resolution assessment of the green, blue and grey water footprint of wheat. Hydrol. Earth Syst. Sci. 14: 1259-1276.

Prajapati, M.R., Patel, V.T., Chaudhary, N.V. and Soni, M.C. (2007). Constraints experienced by growers in adoption of recommended chilli technology. Gujarat Journal of Extension Education. 12 and 13: 56-58.