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Influence of Irrigation Schedules on Yield and Nutrient Uptake of Groundnut Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. Author SC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NVL, MSR and MRB managed the analysis of study. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Evaluation of different irrigation schedules on yield and nutrient uptake of groundnut varieties.
Study Design: The experiment was laid out in split plot design with different irrigation schedules in main plot and different groundnut varieties in sub plots and was replicated thrice.
Place and Duration of Study: The field experiment was conducted during *rabi* season of 2021 and 2022 at the Agricultural College Farm, Bapatla, ANGRAU, Lam, Guntur, Andhra Pradesh.

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Methodology: The experiment was performed with twelve treatments in split plot design. The main plot comprised three different irrigation schedules (IW/CPE ratio of 1.0, 0.8 and 0.6) and sub plot with four different groundnut varieties (TAG-24, Dheeraj, Kadiri Lepakshi and Kadiri Chitravati). Observations of the crop and soil during the experimentation were recorded at regular intervals. The significance of the treatment impact was examined by the test.

Results: The experimental results indicated that among different irrigation schedules, IW/CPE ratio of 1.0 recorded highest pod yield (3175 kg ha^{-1}) and haulm yield (4291 kg ha^{-1}) which was significantly superior over IW/CPE ratio of 0.6 (pod yield-2579 kg ha^{-1} and haulm yield-3681 kg ha^{-1}) but found on a par with IW/CPE ratio of 0.8 (pod yield-2916 kg ha^{-1} and haulm yield-4034 kg ha^{-1}). Among the varieties, Kadiri Lepakshi recorded highest pod yield (3607 kg ha^{-1}) and haulm yield (4647 kg ha^{-1}) which was significantly superior over Kadiri Chitravati, Dheeraj and TAG-24 and lowest pod (2074 kg ha^{-1}) and haulm yield (3424 kg ha^{-1}) was recorded with TAG-24. Highest N, P and K uptake of plant (104.2, 11.8 and 54.3, respectively) was recorded with irrigation scheduled at IW/CPE ratio of 1.0 along with Kadiri Lepakshi compared to the other treatments.

Keywords: Irrigation schedules; groundnut varieties; IW/CPE; yield; nutrient uptake.

1. INTRODUCTION

“The most significant oilseed crop in India is groundnut (*Arachis hypogaea* L.). India is the second-biggest producer in the world after China and the largest nation by area. 9.25 million tonnes are produced annually on 4.9 million hectares of land, with an average productivity of 1893 kg ha^{-1}” [1]. India's top producer, Gujarat, accounts for 43% of the country's total output, followed by Rajasthan (13.76%), Andhra Pradesh (12.28%), Tamil Nadu (10.55%), and Karnataka (9.55%) (5.14 per cent).

Andhra Pradesh grows groundnut on 1.01 million hectares, generating 0.60 million tonnes at a productivity of 1497 kg ha^{-1} [2]. “The reason why groundnut productivity is so low in comparison to the global average is primarily due to the fact that it is grown under moisture stress conditions at different growth stages, regardless of the production environment, irrigation technique, variety, and other cultivation practices” [3]. It is also grown in acidic soils with low levels of N, P, Ca, S, and B as well as insufficient organic matter [4]. Water use efficiency for this crop under irrigated conditions is low due to improper irrigation management.

“The reduction in yield will be greater if severe stress occur during the critical crop growth stages like flowering and pod formation” [5]. Thus “the water management is most important factor because groundnut has specific moisture need due to the unique feature of developing the pods underground” [6]. “Proper irrigation scheduling helps the crop to put good crop growth and yield” [3].

“For scheduling irrigation to groundnut crops in different seasons and soil types, various approaches have been advocated. The evaporative demand from the atmosphere has grown in importance as the primary factor in determining crop water requirements, for which scheduling irrigation to groundnut crops on the basis of a climatological approach based on the IW/CPE ratio (IW- Irrigation Water, CPE- Cumulative Pan Evaporation) has been found to be most appropriate at the present time. This method incorporates all of the weather parameters that influence crop water use and is expected to increase output by at least 15- 20%. Irrigation scheduling optimization resulted in increased pod yield and water use efficiency” [7].

Keeping this in view, the present study was undertaken to investigate the influence of irrigation schedules on yield and nutrient uptake of groundnut varieties.

2. MATERIALS AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla, which is situated at an altitude of 5.49 m above the Mean Sea Level (MSL), 15° 54´N latitude, 80° 30´E longitude and about 8 km away from the Bay of Bengal in the Krishna Agro-climatic Zone of Andhra Pradesh, India. The experiment was laidout in Field No.11, Orchard block of the Agricultural College Farm, Bapatla during *rabi* 2021-22.

The experiment site was a sandy loam soil with neutral in reaction (pH-6.91), low in available nitrogen (191 kg ha^{-1}) and organic carbon content (0.23%), high in available phosphorous (38.4 kg ha^{-1}) and medium in available potassium (283 kg ha^{-1}). The total amount of rainfall received during the crop growth period was 374.7 mm in 21 rainy days. The bulk density of soil at 15 cm depth was 1.51 g cm^{-3}. Moisture percentage at field capacity and permanent wilting point was 14.5% and 7.0%. The experiment was laidout in split plot design with three replications. The main plots consisting of three irrigation schedules *viz*., M_1- IW/CPE ratio of 1.0, M_2- IW/CPE ratio of 0.8 and M_3-IW/CPE ratio of 0.6 and sub plots consisting of four groundnut varieties *viz*., V_1- TAG-24, V_2-Dheeraj, V_3-Kadiri Lepakshi and V_4-Kadiri Chitravati. The crop was sown at a spacing of 22.5 cm × 10 cm. Recommended N, P and K applied to all the treatments uniformly @ 30: 40: 50 kg ha^{-1}. Nitrogen and phosphorus applied through urea and SSP, potassium through muriate of potash. Whole quantity of the phosphorus and half of the nitrogen and potassium applied as basal and remaining half of nitrogen and potassium as top dressing at 25-30 DAS.

Irrigation scheduling was done using a climatological approach (IW/CPE). The open pan evaporimeter was used to record daily pan evaporation. The total amount of water applied to the crop was 410 mm, 340 mm, and 300 mm in IW/CPE ratios of 1.0, 0.8, and 0.6, respectively. Four, three, and two irrigations were given to irrigation schedules of IW/CPE ratio of 1.0, 0.8, and 0.6, respectively along with the pre-sowing irrigation to all the treatments. In each treatment, the irrigation depth was kept constant at 50 mm per irrigation. A measured amount of water was given to each treatment using a Parshall flume with a capacity of 1cusec [8]. The volume of water to be given for each treatment is calculated from the formula:

Volume = Area × Depth

Plant and kernel samples taken at maturity were analyzed for nitrogen (Modified micro kjeldhal method, Piper [9]), phosphorus (Vanadomolybdo phosphoric acid method, Jackson [10]), potassium (Flame photometer method, Jackson [10]). From the chemical analysis data, uptake of the individual nutrient was calculated as shown below. Uptake was calculated by multiplying the nutrient content by the respective dry weight of kernel and haulm and then summed up to represent total nutrient uptake at harvest and expressed as kg ha^{-1}.

Nutrient uptake (kg ha^{-1}) = Nutrient content (%) × Dry weight of kernel/haulm (kg ha^{-1}) / 100

The data on the pod and haulm yield was estimated after harvest of the crop. The data recorded on various parameters of crop was subjected to statistical scrutiny by the method of analysis of variance outlined by Panse and Sukhatme [11].

3. RESULTS AND DISCUSSION

3.1 Yield of Groundnut

3.1.1 Pod yield (kg ha^{-1})

Among the irrigation schedules, the IW/CPE ratio of 1.0 (M_1) produced higher pod yield (3175 kg ha^{-1}) (Table 1) than the IW/CPE ratio of 0.6 (2579 kg ha^{-1}) and was comparable to the IW/CPE ratio of 0.8 (M_2) (2916 kg ha^{-1}). This is most likely due to favourable soil moisture conditions and improved soil moisture availability throughout the crop growth period, which significantly stimulated yield attributes and ultimately pod yield. Similar findings were reported by Shaikh et al. [12], Suresh et al. [13] and Behera et al. [14]. Among the varieties, Kadiri Lepakshi produced the highest pod yield (3607 kg ha^{-1}) and was significantly superior to Kadiri Chitravati (3185 kg ha^{-1}), Dheeraj (2694 kg ha^{-1}) and TAG-24 (2074 kg ha^{-1}). These increased yield attributes could be attributed to increased growth parameters such as branch number and biomass production. The current findings are consistent with those of Mohite et al. [15] and Naik et al. [16].

3.1.2 Haulm yield (kg ha^{-1})

The data (Table 1) revealed that irrigation scheduled at IW/CPE ratio of 1.0 (4291 kg ha^{-1}) recorded higher value of haulm yield, which was significantly superior over IW/CPE ratio of 0.6 (M_3) (3681 kg ha^{-1}) but found statistically on a par with IW/CPE ratio of 0.8 (M_2) (4034 kg ha^{-1}). However, the lowest haulm yield was recorded with IW/CPE ratio of 0.6. This might be attributed to maintenance of adequate available soil moisture in the root zone coinciding with critical growth stages of crop would have helped for proper uptake as well as utilization of nutrients and created a favourable impact on growth as well as yield components leading to better haulm yield of the crop. Similar results were also reported by Bandopadhyay [17] and Chitodkar et al. [18].

Irrigation scheduled at 0.6 IW/CPE treatment recorded the lowest haulm yield (3681 kg ha^{-1}). Reduction in plant height, branches per plant, drymatter accumulation and canopy development due to moisture stress ultimately reduced the haulm yield of groundnut. Similar results were also reported by Sounda et al. [19].

Among the varieties, Kadiri Lepakshi recorded significantly highest haulm yield (4647 kg ha^{-1}) over Kadiri Chitravati (4101 kg ha^{-1}), Dheeraj (3835 kg ha^{-1}) and TAG-24 (3424 kg ha^{-1}). Whereas, Dheeraj and Kadiri Chitravati were comparable with each other. The highest haulm yield by Kadiri Lepakshi might be due to the genetic makeup of the genotype besides the environmental conditions. The results revealed in the present study are in confirm with findings of Nirmal et al. [20].

3.2 Nutrient Uptake

N, P and K uptake by groundnut varieties estimated in kernel and haulm at harvest was significantly influenced by the irrigation schedules, while interaction effect was not statistically significant.

Total nutrient uptake includes nutrient uptake by kernel and haulm. Total N, P and K uptake was maximum when irrigation was scheduled at 1.0 IW/CPE ratio (104.2 kg ha^{-1}, 11.8 kg ha $^{-1}$ and 54.3 kg ha^{-1}, respectively) and was significantly superior than IW/CPE ratios of 0.8 and 0.6. When compared to other treatments, irrigation with an IW/CPE ratio of 0.6 (78.1 kg ha^{-1}, 8.2 kg ha^{-1} and 44.8 kg ha^{-1}, respectively) resulted in the lowest N, P and K uptake. Because N, P and K uptake in plants is a function of yield and concentration, significant uptake by the plant may have resulted in higher yields. A consistent and adequate supply of moisture throughout the crop growth period could be one reason for increased nutrient availability for higher uptake and progressive utilisation by the crop, which in turn modified to produce incremental photosynthates for better partitioning of drymatter from source to sink. These results are in conformity with the findings of Patel et al. [21], Naresha et al. [22] and Verma et al. [23].

Highest uptake of N, P and K found with Kadiri Lepakshi (109.4 kg ha^{-1}, 12.7 kg ha^{-1} and 58.1 kg ha^{-1}, respectively) and was significantly superior over Kadiri Chitravati (V_4), Dheeraj (V_2) and TAG-24 (V_1). The lowest uptake of nitrogen was found with TAG-24 (70.4 kg ha^{-1}, 7.3 kg ha^{-1} and 41.6 kg ha^{-1}, respectively) variety. N, P and K uptake of varieties is mostly governed based on the amount of drymatter produced besides the concentration of nutrient in various plant parts which corroborated the findings of Mohapatra and Dixit [24] and Yadav et al. [25]. The higher uptake of N, P and K was recorded with Kadiri Lepakshi, this might be due to the inherent characterstic feature of the Kadiri Lepakshi variety to absorb greater quantity of nutrients, and among the varieties, variation in uptake may also be due to nitrogen content of different cultivars.

Table 1. Pod yield and haulm yield (kg ha^{-1}) of groundnut varieties as influenced by irrigation schedules during *rabi*, 2021-2022

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Irrigation Schedules (M)		
M_1: IW/CPE ratio of 1.0	3175	4291
M_2: IW/CPE ratio of 0.8	2916	4034
M_3 : IW/CPE ratio of 0.6	2579	3681
SEm ±	84.8	74.5
CD (p=0.05)	333	293
CV (%)	10.2	6.5
Groundnut Varieties (V)		
V_1 : TAG-24	2074	3424
V_2: Dheeraj	2694	3835
V_3: Kadiri Lepakshi	3607	4647
V_4: Kadiri Chitravati	3185	4101
SEm±	110.3	122.2
CD(p=0.05)	328	363
CV (%)	11.5	9.2
Interaction (M × V)	NS	NS

Table 2. Nitrogen uptake (kg ha^{-1}) of groundnut varieties as influenced by irrigation schedules during *rabi*, 2021-2022

Treatments	Nitrogen uptake at harvest (kg ha^{-1})		
	Haulm uptake	Kernel uptake	Total uptake
Irrigation Schedules (M)			
M_1: IW/CPE ratio of 1.0	43.9	60.3	104.2
M_2: IW/CPE ratio of 0.8	41.5	50.0	91.5
M_3 : IW/CPE ratio of 0.6	37.6	40.6	78.1
SEm ±	0 .50	1.01	0.97
CD (p=0.05)	1.97	3.98	3.82
CV (%)	4.24	6.98	3.69
Groundnut Varieties (V)			
V_1 : TAG-24	34.9	35.4	70.4
V_2: Dheeraj	40.3	45.6	85.9
V_3: Kadiri Lepakshi	46.3	63.0	109.4
V_4: Kadiri Chitravati	42.4	57.1	99.5
SEm±	0.78	1.70	2.08
CD(p=0.05)	2.31	5.04	6.18
CV (%)	5.69	10.12	6.84
Interaction (M × V)	NS	NS	NS

Table 3. Phosphorus uptake (kg ha^{-1}) of groundnut varieties as influenced by irrigation schedules during *rabi*, 2021-2022

Treatments	Phosphorus uptake at harvest (kg ha^{-1})		
	Haulm uptake	Kernel uptake	Total uptake
Irrigation Schedules (M)			
M_1: IW/CPE ratio of 1.0	4.7	7.1	11.8
M_2: IW/CPE ratio of 0.8	4.0	6.2	10.2
M_3 : IW/CPE ratio of 0.6	3.3	5.0	8.2
SEm ±	0.09	0.10	0.20
CD (p=0.05)	0.37	0.40	0.79
CV (%)	8.17	5.84	6.88
Groundnut Varieties (V)			
V_1 : TAG-24	2.9	4.4	7.3
V_2: Dheeraj	3.9	5.5	9.3
V_3: Kadiri Lepakshi	5.1	7.6	12.7
V_4: Kadiri Chitravati	4.2	6.9	11.0
SEm±	0.15	0.18	0.25
CD(p=0.05)	0.44	0.54	0.75
CV (%)	11.04	8.98	7.5
Interaction (M × V)	NS	NS	NS

Table 4. Potassium uptake (kg ha^{-1}) of groundnut varieties as influenced by irrigation schedules during *rabi*, 2021-2022

Treatments	Potassium uptake at harvest (kg ha^{-1})		
	Haulm uptake	Kernel uptake	Total uptake
Irrigation Schedules (M)			
M_1: IW/CPE ratio of 1.0	40.6	13.7	54.3
M_2: IW/CPE ratio of 0.8	38.3	12.0	50.3
M_3 : IW/CPE ratio of 0.6	35.2	9.6	44.8
SEm ±	0.56	0.36	0.64
CD (p=0.05)	2.20	1.43	2.50
CV (%)	5.09	10.73	4.42
Groundnut Varieties (V)			
V_1 : TAG-24	33.5	8.05	41.6
V_2: Dheeraj	36.4	10.6	46.9

Treatments	**Potassium uptake at harvest (kg ha^{-1})**		
	Haulm uptake	**Kernel uptake**	**Total uptake**
V_3: Kadiri Lepakshi	43.2	14.9	58.1
V_4: Kadiri Chitravati	39.2	13.6	52.6
SEm±	0.94	0.41	1.04
CD(*P*=0.05)	2.80	1.21	3.09
CV (%)	7.43	10.38	6.27
Interaction (M × V)	NS	NS	NS

4. CONCLUSION

From the present investigation it can be concluded that highest pod (3175 kg ha^{-1}) and haulm yield (4291 kg ha^{-1}) of groundnut was recorded with IW/CPE ratio of 1.0 (M_1) which was significantly superior over IW/CPE ratio of 0.6 (M_3) but was on par with IW/CPE ratio of 0.8 (M_2). Among the varieties, Kadiri Lepakshi (V_3) recorded significantly higher Pod (3607 kg ha^{-1}) and haulm yield (4647 kg ha^{-1}) over Kadiri Chitravati (V_4), Dheeraj (V_2) and TAG-24 (V_1) and Kadiri Chitravati and Dheeraj was found on par with each other. N, P and K uptake of groundnut varieties in both kernel and haulm was found significantly highest with IW/CPE ratio of 1.0 (M_1) along with Kadiri Lepakshi variety (V_3) compared to other treatments. The lowest N, P and K uptake in kernel and haulm was recorded with 0.6 IW/CPE ratio (M_3) along with TAG-24 variety (V_1).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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