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Yield and water use efficiency of summer groundnut *(Arachis hypogaea* L.) as influenced by different irrigation regimes and land configurations

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Abstract
A field experiment entitled, on "Studies on irrigation regimes and land configurations on growth and yield of summer groundnut (*Arachis hypogaea* L.)" was conducted at Agronomy Farm, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur (M.S.), India during summer, 2020. The experiment was laid out in split plot design with three replications and twelve treatment combinations consist of main plot with four irrigation regimes, *viz.*, I_1- 0.6 IW/CPE, I_2- 0.8 IW/CPE, I_3- 1.0 IW/CPE, I_4- 1.2 IW/CPE, and three land configurations *viz.*, L_1- Broad Bed Furrow, L_2- Ridges and furrow, L_3- Flat bed. The analyzed results indicated that application of water at 1.0 IW/CPE was at par with 0.8 IW/CPE and 1.2 IW/CPE significantly superior over 0.6 IW/CPE in respect of yield attributes and yield *viz*., number of pods plant^{-1}, weight of pods plant^{-1} (g), dry pod yield (q ha^{-1}), dry haulm yield (q ha^{-1}), biological yield (q ha^{-1}), shelling (%), weight of 100 kernels (g), sound mature kernel (%) and harvest index (%). For land configurations broad bed furrow recorded significantly superior yield attributes and yield *viz*., number of pods plant^{-1}, weight of pods plant^{-1} (g), dry pod yield (q ha^{-1}), dry haulm yield (q ha^{-1}), biological yield (q ha^{-1}), shelling (%), weight of 100 kernels (g), sound mature kernel (%) and harvest index over flat bed and found at par with ridges and furrows. The significantly highest WUE was obtained with irrigation regimes of 1.0 IW/CPE over 0.6 IW/CPE, and it was at par with 0.8 IW/CPE and 1.2 IW/CPE. For land configuration broad bed furrow recorded significantly superior WUE as compared to flat bed and found at par with ridges and furrows.

Keywords: Irrigation regimes, land configurations, water use efficiency, attribute, summer, *Arachis hypogaea* L.

1. Introduction

Groundnut (*Arachis hypogaea* L.) *is* one of the important legume cash crops for the farmers in arid and semi-arid regions is. In India the oilseeds are economic backbone in agricultural produce. Due it's to importance for oil, protein, food, medicine, and industrial use groundnut is grown all over the world. During 2019-2020 it was sown 50.95 lakh hectares as compared in 2018-2019 was 39.12 lakh ha. Adoption of improved technology is most important to meet the ever-increasing demand of vegetable oil, production improvement of major oilseed crops through area expansion and productivity enhancement. Productivity of groundnut is low in the *kharif* season due to monsoon uncertainties and disease epidemics, which limits its cultivation in the rainy season. Higher and stable yields can be obtained in summer mainly because of bright sunshine, least incidence of insects, pests, and diseases. Consumption of water by irrigation sector is 83% and it can be decreased up to 72% by 2025(Mo WR, 2014) [5]. Therefore, there is need to increase the yields and water use efficiency in water limited environments. Thus, this review will focus on the various water economization practices, irrigation scheduling based on cumulative pan evaporation, land configuration. Optimum scheduling of irrigation led to increase in pod yield and water use efficiency (WUE) (Taha and Gulati, 2001) [12]. Irrigation scheduling can greatly reduce the excess costs of wasting water and fuel without negatively impacting plant growth. Various approaches have been advocated for scheduling irrigation to groundnut crop in different seasons and soil types. The evaporative demand from the atmosphere is regarded crucial in defining the main element in crop water requirements, and it has gained relevance lately (Prihar *et al*., 1974) [10]. Based on irrigation water depth (IW) and cumulative pan evaporation (CPE), a climatological approach can be better utilized to schedule irrigation. Land configuration is critical in determining the efficacy of crop management strategies such as irrigation, nutrient application and weed control among others. Groundnut is having characteristic mechanism i.e., geotropism therefore loose and well aerated soil surface has favorable impact on pod penetration and development. Hence, land configuration is important in planting of summer groundnut. Keeping this in view, an agronomic experiment was conducted to study the effect of irrigation regimes and land configurations growth and yield of summer groundnut in sub-montane zone of Maharashtra.

2. Materials and Methods

A field experiment was conducted at Agronomy Farm, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur (M.S.), India during summer, 2020 to study the effect of irrigation regimes and land configurations on growth and yield of summer groundnut (*Arachis hypogaea L).* The soil of the experimental plot was sandy clay loam in texture, low in available N (171.27 kg ha^{-1}), moderately high in available P_2O_5 (18.26 kg ha^{-1}), medium in available K_2O (183.19 kg ha^{-1}) and slightly alkaline in reaction (pH 7.81). The experiment was laid out in split plot design with three replications and twelve treatment combinations consist of main plot with four irrigation regimes *viz.*, I_1- 0.6 IW/CPE, I_2- 0.8 IW/CPE, I_3- 1.0 IW/CPE, I_4- 1.2 IW/CPE, and sub plot with three land configurations *viz.*, L_1- Broad Bed Furrow, L_2- Ridges and furrow, L_3- Flat bed. The gross and net plot size were 4.80 m x 4.00 m and 3.60 m x 3.00 m, respectively. The Recommended Dose of Fertilizer (NPK Kg ha^{-1}) was applied by using urea and single super phosphate by placement method. The variety of crop JL-1085 (Phule Dhani) was sown on 10th of March 2020 during experimentation by dibbling method at spacing 30 cm × 10 cm with different irrigation regimes and land configurations. The land configuration practices *viz*., broad bed furrow of 150cm with 120 cm top and 30 cm furrow width (L_1), ridges and furrows (60 cm wide ridge, 60 cm wide furrow) (L_2), flatbed method (L_3) were prepared. Three common irrigations, *viz*., first immediately after sowing, second and third at 7 days interval after first irrigation for proper germination and establishment of the plants. The treatments were comprised four irrigation regimes i.e., 0.6, 0.8, 1.0 and 1.2 IW/CPE ratio with 5 cm water depth as main plot. Scheduling of irrigation was done as per CPE values calculated *viz*., 83.4, 62.5, 50 and 41.6 mm in respective plots. Daily evaporation data was recorded from the USWB open pan evaporimeter installed in agrometeorological observatory. In all, 7 (83.4 mm), 9 (62.5 mm), 10 (50 mm) and 12 (41.6 mm) irrigations were applied as per treatments. The experimental data was statistically analyzed by using a standard method of "analysis of variance" as reported by Panse and Sukhatme (1967) [6].

3. Result and Discussion

3.1 Effect on yield attributing characters of groundnut

3.1.1 Effect of irrigation Regimes

Irrigation regimes had a substantial impact on the yield attributing characters of groundnut. Application of irrigation at 1.0 IW/CPE recorded significantly superior number of pods $plant^{-1}$ (47.41g), weight of pod $plant^{-1}$ (47.64g), weight of 100 kernels (47.27g), SMK (78.72%), shelling (67.98%) over irrigation at 0.6 IW/CPE (Table 1). The 0.8 IW/CPE and 1.2 IW/CPE treatments gave at par results with treatment 1.0 IW/CPE. The increase in soil moisture reduces soil strength and facilitates easy movement of pods into the ground either throughout the growing period of crop or during critical period of peg formation and penetration, pod initiation. Plants with a high soil moisture regime gave better growth and development of pods. Similar results were reported by Behera *et al*., (2015) [1] and Naresha *et al*., (2019).

3.1.2 Effect of land configurations

Land configurations had a substantial impact on the yield attributing characters of groundnut. The broad bed furrow recorded significantly maximum number of pods $plant^{-1}$ (47.26g), weight of pod $plant^{-1}$ (45.87g), weight of 100 kernels (46.96g), SMK (78.48%), shelling (67.26%) over flatbed (Table 1). However, it was on par with ridges and furrows. Due to loosened and porous soil in the broad bed furrow, it was easier to store rainwater and have a larger root system, which resulted in higher water and nutrient uptake by the crop. Timely moisture availability led to higher growth of plant and finally gave rise to higher pod filling. The increased number of branches and more reproductive growth and conversion of flowers in pods only due to more conserved soil moisture at peak period of pod development. It might have resulted in increased number of pods per plant. Similar results were observed Subrahmaniyan and Kalaiselvan (2006) [11], and Jaypaul (1996) [3].

3.1.3 Effect of Interaction

The interaction effect between irrigation regimes and land configurations treatments the was found to be non-significant in respect of yield attributing characters of groundnut.

3.2 Effect on yield of groundnut

3.2.1 Effect on irrigation regimes

Irrigation at various regimes had a substantial impact on groundnut dry pod and haulm yield. Among irrigation regimes, the application at 1.2 IW/CPE recorded significantly the highest dry pod yield (27.84 q ha^{-1}) and haulm yield (39.60 q ha^{-1}) of groundnut over 0.6 IW/CPE (Table 2). However, it was at par with application of irrigation at 0.8 IW/CPE and 1.2 IW/CPE for dry pod yield and haulm yield respectively. The lowest dry pod yield and haulm yield was obtained at 0.6 IW/CPE ratio. With the 1.0 IW/CPE ratio, adequate moisture availability combined with higher irrigation frequency resulted in luxurious crop growth and, as a result, raised the values of yield attributes when compared to 0.6 IW/CPE ratio treatment. Higher pod yields with more frequent irrigation (1.0 IW/CPE ratio) might be due to positive impact on yield-related features like number of kernels pod^{-1}, number of pods per plant, 100 kernel weights, and finally leading to highest dry pod yield and dry haulm yield. Similar results were recorded by Pawar *et al*., (2013) [9], Behera *et al*., (2015) [1] and Tambe *et al*., (2017) [13].

Table 1: Yield attributing characters of groundnut as influenced by various treatments at harvest

Treatments	At harvest				
	Number of pods $plant^{-1}$	Weight of pods $plant^{-1}$ (g)	Weight of 100 kernels (g)	SMK (%)	Shelling (%)
Main Plot: Irrigation Regimes					
I_1 - 0.6 IW/CPE	40.81	38.70	40.56	71.69	60.21
I_2 - 0.8 IW/CPE	46.19	46.07	45.35	77.60	66.63
I_3 - 1.0 IW/CPE	47.41	47.64	47.27	78.72	67.98

I_4 - 1.2 IW/CPE	44.24	43.38	44.84	75.44	63.09
S. Em±	1.32	1.52	1.26	1.42	1.61
C. D. at 5%	4.56	5.26	4.38	4.91	5.56
Sub Plot: Land Configurations					
L_1 -Broad Bed Furrow	47.26	45.87	46.96	78.48	67.26
L_2- Ridge and Furrow	44.09	43.83	43.95	75.56	64.31
L_3- Flat Bed	42.64	42.14	42.60	73.54	61.87
S. Em±	1.11	0.98	1.05	1.15	1.37
C. D. at 5%	3.33	2.93	3.15	3.45	4.11
Interaction: I × L					
S. Em±	2.22	1.96	2.10	2.30	2.74
C. D. at 5%	NS	NS	NS	NS	NS
General mean	44.66	43.95	44.51	75.86	64.48

3.2.2 Effect on land configurations
The different land configurations treatments significantly differed in respect of the pod yield and haulm yield. The highest dry pod yield (27.34 q ha^{-1}) and dry haulm yield (38.94 q ha^{-1}) of groundnut was observed in BBF layout, it was significantly superior over flatbed (Table 2). However, it was on par with ridges and furrows layout. The broad bed furrow provided a loose soil mass with sufficient moisture. These conditions favored efficient peg penetration and pod development, which resulted in an increase in groundnut dry pod yield and dry haulm yield. Similar results were recorded by Vekariya *et al*., (2015) [14] and Patil *et al.*, (2007) [8].

Table 2: Mean dry pod yield, dry haulm yield, biological yield and harvest index as influenced by various treatments

Treatments	**At harvest**			
	Dry pod yield (q ha^{-1})	**Dry haulm yield (q ha^{-1})**	**Biological yield (q ha^{-1})**	**Harvest index (%)**
Main Plot: Irrigation Regimes				
I_1- 0.6 IW/CPE	23.38	34.63	58.02	40.31
I_2- - 0.8 IW/CPE	25.84	37.50	63.35	40.87
I_3- - 1.0 IW/CPE	27.84	39.60	67.44	41.20
I_4- - 1.2 IW/CPE	25.10	36.66	61.76	40.61
S. Em±	0.81	0.90	1.27	0.92
C. D. at 5%	2.79	3.13	--	--
Sub Plot: Land Configurations				
L_1 -Broad Bed Furrow	27.34	38.94	66.28	41.20
L_2- Ridge and Furrow	25.76	37.04	62.81	41.06
L_3- Flat Bed	23.53	35.31	58.84	39.99
S. Em±	0.56	0.77	0.81	0.81
C. D. at 5%	1.67	2.30	--	--
Interaction: I × L				
S. Em±	1.11	1.53	1.61	1.62
C. D. at 5%	NS	NS	NS	NS
General mean	25.54	37.10	62.64	40.75

3.2.3 Effect on interaction
The interaction effect between irrigation regime and land configuration was found to be non-significant in respect of yield of summer groundnut.

3.3 Effect on water use efficiency
3.3.1 Effect of irrigation regimes
The different treatments of irrigation regimes had a significant impact on water use efficiency of groundnut. Treatment of irrigation regime 1.0 IW/CPE recorded significantly highest water use efficiency (3.61 kg ha^{-1} mm) over 0.6 IW/CPE. However, it was on par with application of irrigation at 0.8 IW/CPE was (3.35 kg ha^{-1} cm) and 1.2 IW/CPE was (3.26 kg ha^{-1} mm) (Table 3). The least water use efficiency was recorded at 0.6 IW/CPE was (3.03 kg ha^{-1} mm). The WUE was increased with decrease in irrigation interval. The mean highest WUE (3.31 kg ha^{-1} mm) was achieved with 1.0 IW/CPE regime, whereas the lowest was with 0.6 IW/CPE. It could be because of the beneficial effect of providing water at shorter intervals, which increased yield contributing characters and resulted in higher pod yield when compared to other treatments. Similar findings were reported by Patel *et al*., (2008) [7] and Madhuri Devi *et al*., (2019) [4].

3.3.2 Effect of land configurations
The different land configurations treatments influenced differently on water use efficiency. The broad bed furrow of groundnut recorded significantly maximum water use efficiency (3.55 kg ha^{-1} cm), over the flatbed (Table3). However, it was on par with ridges and furrows layout (3.34 kg ha^{-1} mm). The lowest water use efficiency (3.05 kg ha^{-1} mm) was obtained in flatbed. Sowing and irrigation in furrows had the highest water use efficiency compared to flat beds. The broad bed furrow provided a loose soil mass with sufficient moisture. Availability of optimum moisture in modified layout led to higher growth and yield of crop ultimately leading to enhanced WUE. Similar results were reported by Dutta (2006) [2].

3.3.3 Effect of Interaction: The interaction effect between irrigation regimes and land configurations treatments the was found to be non-significant in respect of WUE.

Table 3: Water Use Efficiency (kg ha^{-1} mm) of summer groundnut as influenced by different treatments

Treatments	Water Use Efficiency (kg ha^{-1} mm)
Main Plot: Irrigation Regimes	
I_1- 0.6 IW/CPE	3.03
I_2- - 0.8 IW/CPE	3.35
I_3- - 1.0 IW/CPE	3.61
I_4- - 1.2 IW/CPE	3.26
S. Em±	0.10
C. D. at 5%	0.36
Sub Plot: Land Configurations	
L_1 -Broad Bed Furrow	3.55
L_2- Ridge and Furrow	3.34
L_3- Flat Bed	3.05
S. Em±	0.07
C. D. at 5%	0.22
Interaction: I × L	
S. Em±	0.14
C. D. at 5%	NS
General mean	3.31

4. Conclusion
1. Among different irrigation regimes, scheduling of irrigation at 1.0 IW/CPE recorded the superior dry pod yield and dry haulm yield of summer groundnut, so irrigation at 1.0 IW/CPE found remunerative for groundnut.
2. Among different land configurations Broad Bed Furrow (BBF) recorded the maximum dry pod yield and dry haulm yield of summer groundnut, so adopting broad bed furrow found remunerative for groundnut.
3. Among irrigation regimes irrigation at 1.0 IW/CPE and Broad Bed furrow recorded highest WUE and found remunerative for groundnut.

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