Effect of Water Regimes on the Growth of and Yield of Rabi / Summer Groundnut Genotypes in Northern Transition Zone of Karnataka

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ABSTRACT

Introduction: Groundnut crop grown during Rabi / summer experiences moisture stress, thus irrigation is must. However, water for irrigation gets scarce during summer month hence it becomes important to choose stress tolerant varieties and optimize irrigation schedule without compromising the yield.

Methods: A field experiment with four rabi / summer groundnut genotypes (G₁: Dh-86, G₂: Dh-101, G₃: K-9 and G₄: G2-52) exposed to four irrigation regimes (I₁: 7 irrigations at 15 days interval from sowing to 105 DAS as control, I₂: withdrawal of one irrigation between 45 - 60 DAS i.e., pegging stage, I₃: withdrawal of two irrigations between 45-75 DAS i.e., at pegging and pod filling stage, I₄: withdrawal of four irrigations from 45-105 DAS i.e., at pegging, pod filling and kernel development stage) was carried out from December to April of 2016-17 on black cotton soils at AICRP on Groundnut UAS, Dharwad.

Result: Among the genotypes tested, Dh-86 recorded significantly higher pod yield (2,376 kg ha⁻¹) followed by Dh-101 (2,215 kg ha⁻¹) and K-9 (2,048 kg ha⁻¹), whereas G2-52 gave the lowest yield (1,880kg ha⁻¹) and all of them performed well at I₁ and I₂ irrigation regimes. Among different water regimes, I₁ (i.e., control) recorded significantly taller plants, higher LAI, more branches and higher dry matter at harvest as compared to other irrigation regimes, hence it also recorded significantly higher pod yield and haulm yield (2,870 and 4,691 kg ha⁻¹, respectively), but was found at par with I₃, i.e., crop stressed only at pegging stage (2,858 and 4,648 kg ha⁻¹, respectively). This suggests that, at the most, one irrigation can be skipped at pegging stage without compromising on yield.

Key words: Genotypes, Groundnut, Haulm yield, Leaf area index, Pod yield, Water regimes.

INTRODUCTION

Groundnut is the world’s fourth most important source of edible oil and third most important source of vegetable protein. It is grown throughout the tropical and warm temperate regions of the globe. It is a unique crop, having the attributes of both oilseed and legume crop in the farming system. It is a valuable crop cultivated in dry areas of Asia, Africa, Central and South America, Australia and the Caribbean due to its economic and nutritional value. The kernel of groundnut contains 46-52 per cent oil, 18 per cent carbohydrates, 25-30 per cent crude protein, 5 per cent fiber and ash which make it an important component of human nutrition and also a valuable source of vitamin E and K. It is the richest plant source of thiamine and niacin, which are low in cereals. Currently groundnut is grown on nearly 27.94 m h around the world with an annual production of 47.09 m t (Anon., 2018). In India, during 2017-18, groundnut was being cultivated over an area of 4.88 m ha with a total production of 9.25 m t with a productivity of 1,893 kg ha⁻¹ (Anon., 2019).

Karnataka ranks fifth in the country with a production of 5.55 m t from an area of 0.56 m ha and at an average yield of 980 kg ha⁻¹ (Anon., 2019) which is much lower to national average. This is because groundnut production is mostly grown in rainfed areas of both arid and semi arid tropics...
post-monsoon season, i.e., rabi/summer season, irrigation water is must which is a scarce resource, hence needs to be judiciously utilized for efficient and economic crop production. At the same time choice of stress tolerant genotypes is also required to take up economically profitable production. In this study four varieties namely G1: Dh-86, G2: Dh-101, G3: K-9 and G4: G2-52, of which first three are season specific (rabi / summer) and the fourth one is very popular among the farmers are chosen. Therefore, this study was undertaken with two objectives: i) to quantify the possibility of reducing irrigation without compromising yield and ii) to test selected genotypes for their performance under different moisture stress levels on medium black soils.

**MATERIALS AND METHODS**

A field experiment was conducted during rabi/summer season (December to April) 2016-17 at AICRP on groundnut UAS, Dharwad located at 15°26’ North latitude, 75°07’ East longitude and at an altitude of 678 m above mean sea level (MSL). It lies under the Northern Transition Zone (Zone-8; NTZ) of agro-climatic zones of Karnataka on medium deep black soil. The experiment was laid out in split plot design with three replications involving four water regimes viz. I1: Control, i.e., seven irrigations at 15 days interval from sowing to 105 days after sowing (DAS), I2: Stress at pegging stage by withdrawal of one irrigation at 45-60 DAS, I3: Stress at pegging and pod filling stage with withdrawal of 2 irrigations at 45-75 DAS, I4: Stress at pegging, pod filling and kernel development stage i.e., withdrawal of 4 irrigations from 45-105 DAS as main plots and four genotypes as sub plots viz. G1: Dh-86, G2: Dh-101, G3: K-9 and G4: G2-52. The soil of the experimental site was medium black clay with pH (7.43), EC (0.21 dS m⁻¹), organic carbon content was (0.56%), available N (249 kg ha⁻¹), P₂O₅ (23 kg ha⁻¹) and K₂O (359 kg ha⁻¹). The mean monthly rainfall from September to April for the past 66 years at the Main Agricultural Research Station, Dharwad was 351.4 mm whereas the rainfall received during September - April 2016 was 127.4, which is much lower than long-term average. The crop was sown on December 28th 2006 and the temperatures during the crop growing season (January to April), mean maximum temperature for January, February and March were 4.4, 1.8, 0.6 and 0.0°C higher than long term average. Whereas mean minimum temperature was 1.5 and 1.0 higher during January and February but 3.7 and 0.5°C lower during March and April, respectively, compared to long term mean monthly averages (1950 to 2015).

Bold and healthy groundnut seeds were hand dibbled and covered with soil. At the time of sowing surface irrigation (flooding), subsequently sprinkler irrigation at 15 days intervals was followed as per the treatment. The height was measured at harvest in centimeters from the base to the tip of the plant. Leaf area was measured by disc method as suggested by Vivekanandan et al. (1972) and it was calculated by using formula: LA = Weight of all leaves + discs X Area of disc (dm²) / Weight of 50 discs. Leaf area index was calculated by dividing leaf area plant⁻¹ by the land area occupied by a single plant. Pods were dried completely (up to 8% moisture level) and weighed. On the basis of pod yield of net plot the pod yield ha⁻¹ was calculated and expressed in kg ha⁻¹. The analysis and interpretation of data were studied using the Fischer’s method of analysis of variance technique as described by Gomez and Gomez (1984).

**RESULTS AND DISCUSSION**

Growth parameters of groundnut are significantly influenced by different water regimes and genotype. Among the different water regimes, stress at pegging stage (I2) recorded significantly higher pod yield and haulm yield (2,858 kg ha⁻¹, 4,648 kg ha⁻¹, respectively). However, it was on par with (I1, water regime) no moisture stress crop (2,870 kg ha⁻¹ and 4691 kg ha⁻¹, respectively) (Table 3). Withholding of two irrigations at pegging and pod development stage (I3) and withholding of irrigation at pegging, pod filling and kernel development stage (I4), drastically reduced pod yield to the extent of 32.04 % (1,950 kg ha⁻¹) and 70.64% (842 kg ha⁻¹) respectively, over no moisture stress (I1) (Table 3). It might be due to inadequate availability soil moisture at reproductive stages, like pod filling and kernel development stages, two critical stages of crop which will hinder the translocation of photosynthates from leaves to fruiting parts and pod affecting the pod formation and pod yield.

The higher pod yield and haulm yield in I1 was due to better performance of growth attributes. I1 (Control, 7 irrigations at 15 days interval from sowing to 105 DAS) recorded significantly higher plant height, leaf area, leaf area index, number of branches plant⁻¹, dry matter in stem, dry matter in leaves and total dry matter production at harvest (22.3 cm, 11.76 dm² plant⁻¹, 3.92, 7.52, 15.66, 8.06 g and 33.87 g, respectively) as compared to other water regimes (Table 1, 2 and 3). However, it was found on par with the treatment of I2 (Stress at pegging stage: withdrawal of one irrigation between 45 - 60 DAS). Higher leaf area and leaf area index (Table 1) exposed higher surface area for assimilation of photosynthetic ability and higher dry matter production plant⁻¹(Vaghasia, 2010).

Moisture stress at pod filling and kernel development stage brings premature closer of stomata to reduce water loss, but also decrease carbon dioxide diffusion in to leaves, thereby affecting the photosynthesis (Asana and Sani, 1985). Moisture stress also causes dehydrogenesis of protoplasm causing reduction in photosynthetic rate which ultimately reduces plant height, leaf area, leaf area index, number of branches plant⁻¹, dry matter in stem, dry matter in leaves and dry matter in pods at harvest in I2 (Stress at pegging and pod filling stage i.e., withdrawal of 2 irrigations at 45-75 DAS and I4 (Stress at pegging, pod filling and kernel development stage i.e., withdrawal of 4 irrigations between 45 - 105 DAS). Peanut yield is influenced by the availability of soil moisture during vegetative and reproductive stages and crop experiencing drought during the reproductive phase shows significant yield reductions (Singh, 2011).

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### Table 1: Plant height, Leaf area and Leaf area index of groundnut as influenced by different irrigation regimes and genotypes at harvest.

| Treatment | Plant height (cm) at harvest | Leaf area (dm² plant⁻¹) at harvest | Leaf area index at harvest |
|-----------|-----------------------------|-----------------------------------|---------------------------|
| Irrigations (I) | l₁ | l₂ | l₃ | l₄ | Mean | l₁ | l₂ | l₃ | l₄ | Mean | l₁ | l₂ | l₃ | l₄ | Mean |
| Genotypes (G) | G₁ | 22.2 | 21.3 | 18.4 | 15.7 | 19.4 | 12.52 | 12.01 | 11.17 | 10.52 | 11.55 | 4.17 | 4.00 | 3.72 | 3.51 | 3.85 |
|              | G₂ | 21.6 | 20.6 | 18.1 | 15.2 | 18.9 | 11.90 | 11.64 | 9.73 | 10.25 | 10.88 | 3.97 | 3.88 | 3.24 | 3.42 | 3.63 |
|              | G₃ | 24.4 | 23.4 | 20.7 | 17.1 | 21.4 | 11.41 | 11.33 | 9.98 | 10.34 | 10.77 | 3.80 | 3.78 | 3.33 | 3.45 | 3.59 |
|              | G₄ | 21.0 | 20.6 | 16.5 | 13.4 | 17.9 | 11.20 | 11.29 | 10.47 | 9.88 | 10.71 | 3.92 | 3.86 | 3.45 | 3.42 | 3.57 |
| Mean         |     | 22.3 | 21.5 | 18.4 | 15.4 |     | 11.76 | 11.57 | 10.34 | 10.25 |     | 3.92 | 3.86 | 3.45 | 3.42 |     |

For comparing means of Irrigation (I)
| S.Em. ± | C.D. (P = 0.05) |
|---------|-----------------|
| I₁      | 0.49            |
| I₂      | 2.20            |
| I₃      | 0.20            |
| I₄      | 0.91            |

For comparing means of Genotypes (G)
| S.Em. ± | C.D. (P = 0.05) |
|---------|-----------------|
| G₁      | 0.51            |
| G₂      | 1.48            |
| G₃      | 0.21            |
| G₄      | 0.60            |

I × G
| 0.07 | 0.30 |

**I – Irrigations**: I₁: Control : 7 irrigations at 15 days interval from sowing to 105 DAS.
I₂: Stress at pegging stage : withdrawal of one irrigation between 45 - 60 DAS.
I₃: Stress at pegging and pod filling stage : withdrawal of 2 irrigations between 45 - 75 DAS.
I₄: Stress at pegging, pod filling and kernel development stage : withdrawal of 4 irrigations between 45 - 105 DAS.

**G – Genotypes**
G₁: Dh-86 G₂: Dh-101 G₃: K-9 G₄: G2-52, DAS: Days after sowing NS: Non-significant.

### Table 2: Number of branches plant⁻¹, dry matter in stem and dry matter in leaves of groundnut as influenced by different irrigation regimes and genotypes at harvest.

| Treatment | Number of branches plant⁻¹ at harvest | Dry matter in stem (g plant⁻¹) at harvest | Dry matter in leaves (g plant⁻¹) at harvest |
|-----------|--------------------------------------|------------------------------------------|------------------------------------------|
| Irrigations (I) | l₁ | l₂ | l₃ | l₄ | Mean | l₁ | l₂ | l₃ | l₄ | Mean | l₁ | l₂ | l₃ | l₄ | Mean |
| Genotypes (G) | G₁ | 8.10 | 7.54 | 7.25 | 6.95 | 7.46 | 16.88 | 15.39 | 14.79 | 14.13 | 15.30 | 8.22 | 8.18 | 7.92 | 6.85 | 7.79 |
|              | G₂ | 7.53 | 7.44 | 7.20 | 6.50 | 7.17 | 15.61 | 15.36 | 14.75 | 13.34 | 14.76 | 8.18 | 7.80 | 7.13 | 6.67 | 7.45 |
|              | G₃ | 7.29 | 7.27 | 7.11 | 6.97 | 7.16 | 15.21 | 15.14 | 14.20 | 13.87 | 14.60 | 8.15 | 7.87 | 7.22 | 6.43 | 7.42 |
|              | G₄ | 7.17 | 7.13 | 7.07 | 6.70 | 7.02 | 14.93 | 14.86 | 14.26 | 13.59 | 14.41 | 7.70 | 7.77 | 7.17 | 6.47 | 7.28 |
| Mean         |     | 7.52 | 7.35 | 7.16 | 6.78 |     | 15.66 | 15.19 | 14.50 | 13.73 |     | 8.06 | 7.91 | 7.36 | 6.60 |     |

For comparing means of Irrigation (I)
| S.Em. ± | C.D. (P = 0.05) |
|---------|-----------------|
| I₁      | 0.08            |
| I₂      | 0.26            |
| I₃      | 0.14            |
| I₄      | 0.41            |

For comparing means of Genotypes (G)
| S.Em. ± | C.D. (P = 0.05) |
|---------|-----------------|
| G₁      | 0.10            |
| G₂      | 0.28            |
| G₃      | 0.14            |
| G₄      | 0.41            |

I × G
| 0.13 | 0.36 |

**I – Irrigations**: I₁: Control : 7 irrigations at 15 days interval from sowing to 105 DAS.
I₂: Stress at pegging stage : withdrawal of one irrigation between 45 - 60 DAS.
I₃: Stress at pegging and pod filling stage : withdrawal of 2 irrigations between 45 - 75 DAS.
I₄: Stress at pegging, pod filling and kernel development stage : withdrawal of 4 irrigations between 45 - 105 DAS.

**G – Genotypes**
G₁: Dh-86 G₂: Dh-101 G₃: K-9 G₄: G2-52, DAS: Days after sowing NS: Non-significant.
Efficient utilization of the physiological traits for improving drought resistance in a groundnut requires an understanding of the inheritance and genetic relationships of the traits that are available for selection of genotypes, which is needed to identify the heritability of physiological traits related to drought resistance under different drought conditions (Cruckshank et al., 2004, Williams, 1998, Nigam et al., 2005). Groundnut yield differed significantly among the genotypes. The genotype Dh-86 (2,376 kg ha⁻¹) recorded significantly superior pod yield over other genotypes viz., Dh-101 (2,215 kg ha⁻¹), K-9 (2,048 kg ha⁻¹) and G2-52 (1,880 kg ha⁻¹). The yield of Dh-86 was more to the extent of 6.8, 13.8 and 20.8 per cent, respectively, compared to Dh-101, K-9 and G2-52. With Dh-86 increase in the pod yield (2,376 kg ha⁻¹) and haulm yield (3,816 kg ha⁻¹) was due to higher growth parameters observed during the cropping period.

At harvest, significantly taller plant height (19.4 cm), higher leaf area (11.55 dm² plant⁻¹), leaf area index (3.85), number of branches plant⁻¹ (7.46), dry matter in stem (15.30 g plant⁻¹), leaves (7.79 g plant⁻¹) and total dry matter production (32.10 g plant⁻¹) was observed in the genotype Dh-86 compared to other genotypes mainly due to difference in their genetic makeup of the genotype (Table 1, 2 and 3). It shows that Dh-86 genotype has more resistance to moisture stress and G2-52 was more sensitive to moisture stress. That is why there was reduction in the yield and growth attributes compared to other genotypes. In line with these results, significant genotypic variation for the traits related to drought tolerance was reported in numerous reports depending upon the material used in the study for groundnut genotypes (Vorasoot et al., 2003; Puangbut et al., 2009; Painwade et al., 2009).

Interaction effects indicated that I × G, i.e., seven irrigations at 15 days interval given to genotype Dh-86 recorded higher yield (3191 kg ha⁻¹), but this treatment interaction was found at par with I × G, i.e., skipping one irrigation at 45-60 DAS for Dh-86 (3168.0 kg ha⁻¹). However, skipping more irrigation reduced yield of all the genotypes including Dh-86 (Table 3).

**CONCLUSION**

The study showed that, among the four genotypes tested here in *rabi* / summer season groundnut requires regular irrigation i.e., seven irrigation at 15 days interval to realize higher yield, but at the most one irrigation can be skipped, i.e., at pegging stage between 45 and 60 DAS, yet record at par yields with that at seven irrigations. Any further reductions in number of irrigations will only significantly reduce the yield. This study also revealed that some genotypes are better at tolerating moisture stress than others as in this study Dh-86 performed better than others when fully irrigated and also when one irrigation was skipped at pegging stage.

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