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Research article

RELATIVE WATER CONTENT AS INFLUENCED BY VARIED PLANT DENSITIES AND IRRIGATION LEVELS IN PIGEONPEA

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ABSTRACT: A field experiment was conducted on a sandy clay soil at Agricultural Research Station, Basanthpur, Medak district of Andhra Pradesh during the *kharif* seasons of 2009-'10 and 2010-'11 to study the variation in relative water content (RWC) of pigeonpea (*Cajanus cajan* (L) Mill Sp.) as influenced by plant densities and supplemental irrigation through drip. Three varied plant densities of pigeonpea (D_1–55,555 plants ha^{-1}, D_2–41,666 plants ha^{-1} and D_3–33,333 plants ha^{-1}) were tested as 3 main treatments with 4 irrigation levels as sub treatments involving control (I_1 - rainfed), drip irrigation at flowering with 20 mm depth of water (I_2), drip irrigation at pod development with 20 mm depth of water (I_3) and drip irrigation at flowering and pod development with 20 mm depth of water at each stage, respectively (I_4). The RWC was estimated at 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest. Daily evaporation and rainfall were also recorded at the experimental site. The crop in lower plant density of D_3 had higher relative water content in comparison to D_2, intermediate and D_1, higher plant densities at flowering and pod development stages irrespective of the irrigation treatments imposed. Further, supplemental irrigation at flowering and pod formation stages showed marginal rise in the relative water content irrespective of densities. Lowest relative water content was recorded under non-irrigated rainfed control (I_1) at higher plant densities of D_1 both at flowering and pod development stages.

Key words - Pigeonpea, supplemental irrigation, plant densities, relative water content

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L) Mill Sp.) is a perennial member of the Fabaceae family, and one of the major legume crops of the tropics and subtropics (Vanaja et al. 2010). Compared with other legumes, pigeonpea ranks only the sixth in area and production in the world, but it is used in more diverse ways than others (Wu et al. 2009 and Domoguen et al. 2010). In India, pigeonpea is second most important pulse crop next to Chickpea producing 2.36 million tons annually from 3.56 million ha accounting for 15.5% and 14.5% of pulse production and area in the country, respectively (Singh et al. 2009).

Global yield losses due to drought have been estimated to be around 1.8 million t of pigeonpea (Subbarao et al. 1995). Occurrence of mid-season and terminal droughts of 1 to 3 weeks consecutive duration during reproductive period happens to be the dominant reason for crop (and investment) failures and low crop yields (Rijks, 1986). The challenge is to harvest the monsoon rains during excess rainy events and reuse efficiently during dry spells for improving the yield and income per drop of rainwater (Smith, 2000). Limited amount of irrigation in semi-arid Telangana region could be scheduled to partially alleviate potential plant stress at critical growth stages, although it would likely be deficient to fully meet evapotranspiration needs (Pathak et al. 2009). Rainfall would be relied upon to supply the remainder of the crop's water needs.

Plant density is an important agronomic factor that manipulates micro environment of the field and affects growth, development and yield of crops. Within certain limits, increase of plant population density decreases the growth and yield per plant but the reverse occurs for yield per unit area (Caliskan et al. 2007). The chosen crop spacing is based on the hypothesis that optimal population density allows interception of all (i.e., $\geq 95\%$) of the available photosynthetically active radiation to give the highest yield. No further yield advancement with further increase of population density can occur (Duncan, 1986) because of decrease in radiation use efficiency at higher population density (Gardner et al. 1985). Increasing the plant density per unit land area increases the competition among the plants for growth resources viz., light, water, nutrients and space. Hence, consideration of competition among the plants is important because, too high or too low plant density per unit land area results in reduction in crop yield. So, the plant population decides the overall pressure on the resources, which inturn largely determines the extent to which resources are used. Thus, an optimum plant population which provides best environment to the plant to express its full potential and ensure minimum competition among the plants that makes better use of resources resulting in a yield advantage. Plant metabolism is also dependent on leaf water status, as measured by e.g. relative water content (RWC) (Sinclair & Ludlow, 1985). Selecting plants for high biomass production under drought requires finding a compromise between maximization of C assimilation (with high leaf area and stomatal conductance), and or minimization of transpiration for maintenance of high leaf RWC (with low leaf area and stomatal conductance). RWC has been proposed as a selection criterion for drought tolerance in many crops (Matin, Brown & Ferguson (1989) in barley; Schonfeld et al. (1988) in wheat; Kimani, Benzioni & Ventura (1994) in pigeonpea) and is also an important

MATERIALS AND METHODS

The experiment was conducted during *kharif* seasons of 2009-10 and 2010-2011 at Agricultural Research Station, Basanthpur-Mamidigi, Medak, Andhra Pradesh, India. The site is geographically situated at 17° 45' 52" N–Latitude, 77° 32' 38" E–Longitude and at an altitude of 626 m above mean sea level. Agro-climatologically the area is classified as Central Telangana Agro Climatic Zone of Andhra Pradesh. The soil was sandy clay in texture, slightly acidic in soil reaction and belonged to S1 salinity class. The chemical properties of soil revealed that the soil was low in nitrogen and phosphorus, and medium in potassium. The hydraulic conductivity varied from 1.64 cm hr^{-1} to 2.59 cm hr^{-1}. The total plant available soil water *i.e.*, the difference between 0.1 bar and 15 bars in 0-100 cm soil depth amounted to 84.8 mm m^{-1}. There were 3 varied plant densities of Pigeonpea (D_1–55,555 plants ha^{-1}, D_2–41,666 plants ha^{-1} and D_3–33,333 plants ha^{-1}) tested as 3 main treatments with 4 sub treatments involving control (I_1 - rainfed), drip irrigation (20 mm) at flowering (I_2), drip irrigation (20 mm) at pod development (I_3) and drip irrigation at flowering (20 mm) and pod development (20 mm) (I_4) stages. The flowering in pigeonpea occurs over a period of time and there is no specific date for it. Hence, the irrigation given to sub- treatment I_2 was distributed evenly over a period of 5 days commencing from 50% flowering. Subsequently irrigation at pod development (I_3) was distributed evenly over a period of 5 days commencing from end of flowering. Irrigation water from manifolds flowed in to 16 mm dripperlines laid out on the ground surface along the crop rows with emitters spaced 40 cm apart delivering 4 L hr^{-1}. Pigeonpea (Variety- LRG 41) was sown on 18.07.2009 and 17.07.2010 with the receipt of 32.2 mm and 13.2 mm rain during the growing seasons of 2009 and 2010, respectively. The relative water content was estimated by the method of Barrs and Weatherly (1962). Ten leaf discs were collected randomly in each treatment and weighed accurately upto third decimal on a single pan analytical balance. This was considered as fresh weight. The weighed leaf discs were allowed to float on distilled water in a petri dish and allowed to absorb water for six hours. After six hours, the leaf discs were taken out and their surface was blotted gently and weighed. This was referred to as turgid weight. After drying in hot air oven at 72 ^{0}C for 48 hours, the dry weight was recorded and RWC in per cent was calculated by using the following formula -

$$\mathrm{RWC} = \frac{\mathrm{Fw - Dw}}{\mathrm{Tw - Dw}} \times 100\ (\%)$$

Where,

Fw = Fresh weight,
Dw = Dry weight
Tw = Turgid weight

RESULTS AND DISCUSSION

Relative water content as influenced by plant densities and irrigation levels for 2009 and 2010 is depicted through Figure 1 to 4.

Effect of plant densities

Relative water content under all the plant densities was primarily a function of rainfall events up to flowering in both the years. Thereafter the relative water content varied marginally with the plant densities. Nevertheless the crop in lower plant density of D_3 (33,333 plants ha^{-1}) had higher relative water content in comparison to D_2, intermediate (41,666 plants ha^{-1}) and D_1, higher plant densities (55,555 plants ha^{-1}) at flowering and pod development stages. Further supplemental irrigation at flowering and pod formation stages showed marginal rise in the relative water content irrespective of densities. The mean relative water content was 65.5%, 65.6% and 67.7% under D_1, D_2 and D_3, respectively (Figure 1 and 2).

Effect of irrigation levels

Relative water content under all the irrigation levels was primarily a function of rainfall events up to flowering in both the years (Figure 3 and 4).

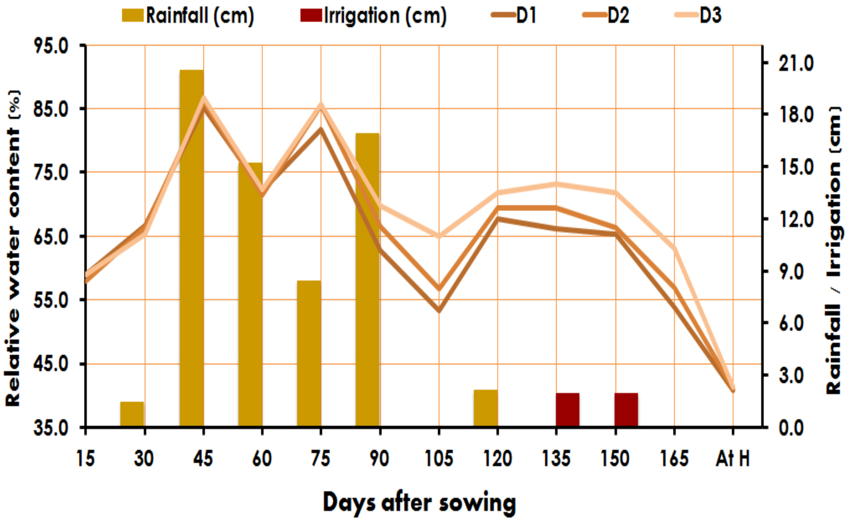

Figure 1. Variation in Relative Water Content (%) as influenced by plant densities during 2009

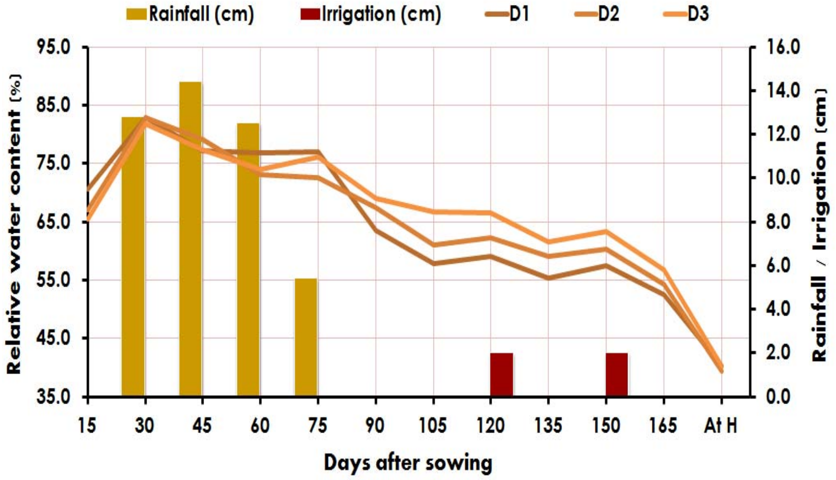

Figure 2. Variation in Relative Water Content (%) as influenced by plant densities during 2010

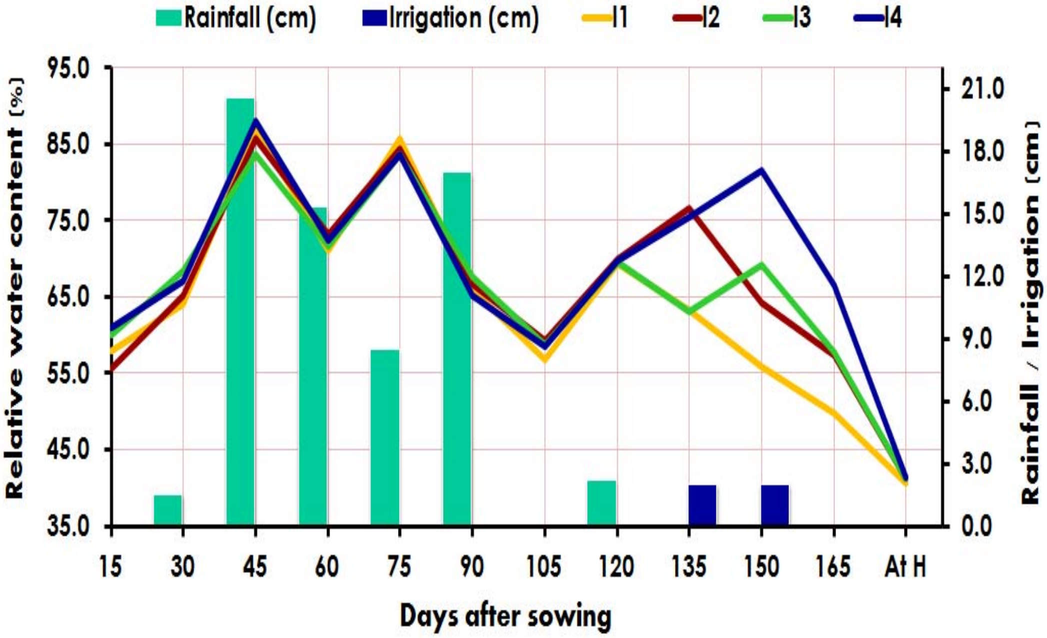

Figure 3. Variation in Relative Water Content (%) as influenced by irrigation levels during 2009

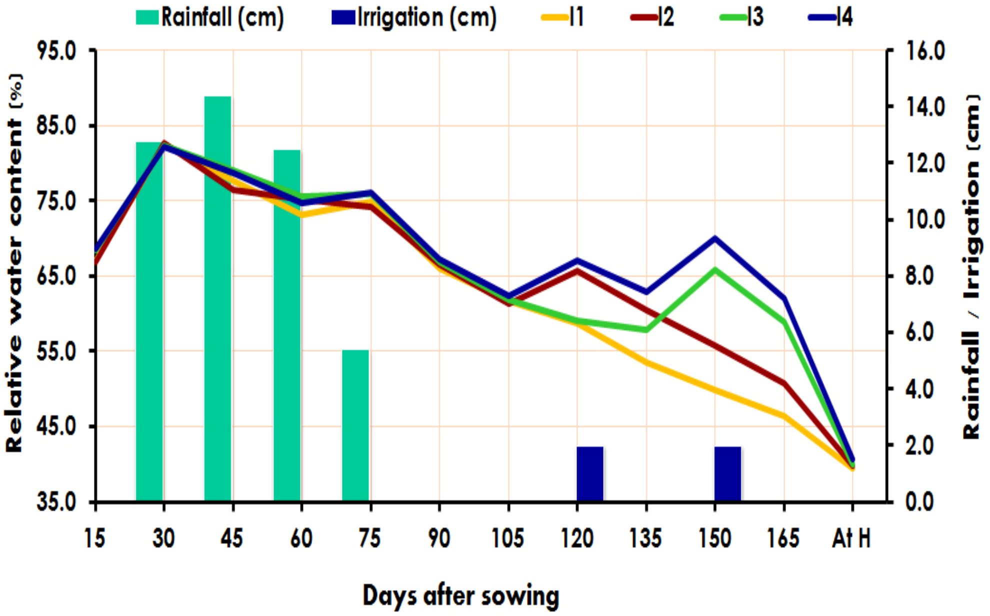

Figure 4. Variation in Relative Water Content (%) as influenced by irrigation levels during 2010

Thereafter the relative water content varied markedly as a function of applied irrigation water. Expectedly the I_4 treatment wherein two irrigations of 20 mm depth each were applied at flowering and pod development stage had higher relative water content over I_1, I_2 and I_3 treatments. Further it was noticed that application of irrigation equivalent to 20 mm depth at flowering in case of I_2 raised the relative water content of crop over I_3 and I_1 at flowering stage. Likewise application of 20 mm depth of water at pod development stage in I_3 treatment raised the relative water content over I_2 and I_1.

Lowest relative water content was recorded under non-irrigated rainfed control (I_1) both at flowering and pod development stages. The mean relative water content was 63.3%, 65.7%, 66.1% and 68.5% under I_1, I_2, I_3 and I_4 respectively. Rainfed control (I_1) reported lowest RWC at moisture stress conditions. Similar findings were by Kumar et al. (2011)., Bayoumi (2008) and Subbarao et al. (2000).

CONCLUSION

Overall, results indicated that pigeonpea grown under relatively lower plant densities recorded higher RWC compared to higher plant densities under rainfed conditions. This theorem holds good irrespective of rainfed, supplemental irrigations at moisture sensitive stages such as flowering and pod development. Further, irrespective of planting densities adopted, the RWC is higher for plants subjected to supplemental irrigation at both the moisture sensitive stages under the conditions evaluated.

Research on supplemental irrigation in pigeonpea at varied plant densities assumes significance under rainfed conditions wherein serendipitous circumstances dictate crop performance. Drought stress tolerance is an attribute of crop that is largely indicated by RWC. Efforts to sustain RWC of pigeonpea at optimal levels makes the crop endure drought stress, thus contributing to yield and crop sustenance in the long run under rainfed conditions. Leaf flaccidity is a long term effect of a drought prone crop and contributes to yield loss and occasionally to crop failure when long drought prevails. On the other hand, turgidity of vegetative parts is important especially under rainfed cultivation so as to endure drought stress and contribute to sustainable yields. These results are useful in determining the planting densities of pigeonpea under rainfed situations and the quantum of supplemental irrigation to be given to the crop so as to maintain RWC at reasonable levels. Future research is directed in determining the quantum of water to be irrigated at each of the drought sensitive stages of pigeonpea and suggest concrete supplemental irrigation schedule to pigeonpea under different planting densities under rainfed conditions.

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