International Journal of Plant and Animal Sciences Vol. 1 (1), pp. 005-010, March, 2013. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Influence of water stress and benzyl adenine imposed at various growth stages on yield of groundnut

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Accepted 20 December, 2012

Transient water deficit stress was imposed on peanut (*Arachis hypogaea* L.) at different phenophases for different durations, water stress at vegetative stag (20 days after sowing), pegging stage (45 days after sowing) and at pod development stage (65 days after sowing). Stress was imposed for 20 days. Transient water deficit stress at all phenophase resulted decline in pod weight per plant, pod yield, Shelling percentage, haulm yield and biological yield. The maximum haulm yield and biological yield was recorded in cv. GG-2. The haulm yield and biological yield were declined under drought conditions at all crop growth stages. The highest haulm yield and biological yield was observed in benzyl adenine soaked seed followed by drought conditions at vegetative stage. Greater harvest index was observed at pegging and pod development stage under drought conditions. Benzyl adenine soaked seed treatment alone reduced the harvest index as compared to control, while, benzyl adenine followed by drought at vegetative stage significantly improved the harvest index. Benzyl adenine soaking seed treatment significantly improved the pod yield, haulm yield and biological yield under drought conditions and greater positive effect of benzyl adenine was recorded under drought conditions at vegetative stage followed by pod development and pegging stage.

Key words: Benzyl adenine, biological yield, haulm yield, harvest index, peanut (*Arachis hypogaea* L), pod weight, pod yield, relative water content and shelling percentage, water stress.

INTRODUCTION

Peanut (*Arachis hypogaea* L), a major oil seed crop is cultivated predominated under rain-fed conditions in the semi-arid tropics. The crop is subjected to soil moisture deficits of varying degree and duration, which occasionally result in substantial loss of yield. Therefore, to develop the drought tolerant cultivars of peanut assumed considerable importance. Water use by groundnut in different cropping seasons in different parts of the world varies between 250 mm under rain fed conditions (Angus et al., 1983) to 831 mm under irrigated conditions (Nageswara et al., 1985). The average yields (1,400 kg/ha) of the summer season crop are almost double those obtained in the rainy season (Nautiyal et al., 2002). Therefore, the contribution of summer season crops to total production is about 45%. The key factor affecting growth and yield is the availability of moisture during the cropping season (Dhruve, 2011). Therefore, improvement for drought tolerance in peanut is vital to stabilize the yield to previously unsuited regions and seasons.

Water deficit stress induces early senescence in crops and decrease the chlorophyll content (Singh et al., 2000). This decrease in yield of crop plants varies with distribution of rainfall particularly in rain fed crops. Therefore, this study is important in a plant like peanut where pod yield are important. Beneficial effects of benzyl adenine under moisture deficit stress conditions have been reported to increase chlorophyll content, photosynthesis and rubisco activity (Dong et al., 1997; Singh et al., 2000). The role of benzyl adenine (BA) is apparently on regulation of some physiological and metabolic activities in crop plants. The research on drought resistance has been very slow and its success

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Abbreviations: BY; Biological yield, **HY;** haulm yield, **HI;** harvest index, **RWC;** relative water content.

through plant breeding seems very difficult in near future. Attempts were, therefore, made in the present experiment on to study the effects of benzyl adenine and PEG induced stress on membrane injury (MI), pod weight, pod yield, shelling percentage, haulm yield (HY) and biological yield (BY) HI in peanut cultivars.

MATERIALS AND METHODS

The experiment was conducted with three Spanish cultivars of peanut (*Arachis hpogaea* L.), GG 2, GG 7 and J 11 during the summer season. The study was carried out at the research farm of the Junagadh Agricultural University at Junagadh (Lat 21.5° N and 70.5° E). The soil of the experiment site was clayey in texture and slightly alkaline (pH 8.0) in reaction having normal electrical conductivity. The crop was sown in 5 × 3 m Main plot and 4.0 × 2.7 m Subplots with 30 cm between rows and 10 cm between plants within rows. Each experiment was a 3 × 9 factorial (Three genotypes and nine drought treatments) arranged in a split plot design with four replications. After sowing, the crop was irrigated twice to ensure good emergence. Recommended agronomic practices and plant protection measures were followed, except for the irrigation schedules, when soil moisture deficit stress was imposed by withholding irrigation during different phenophases for specific durations:

(i) Main plot treatments: Three varieties V_1 = GG-2; V2 = GG-7; V3 = J-11
(ii) Sub-plot treatments: Water stress: 5 levels

T_1 = Control, crop received irrigation regularly at every 10 days interval
T_2 = Seeds were soaked in distilled water for 6 h
T_3 = Seeds were soaked in benzyl adenine (100 mg/L) for 6 h
T_4 = Water stress for 20 days at vegetative stage (20 to 40 DAS)
T_5 = T_4 + Seeds were soaked in benzyl adenine (100 mg/L) for 6 h
T_6 = Water stress 20 days at pegging stage (45 to 65 DAS)
T_7 = T_6 + Seeds were soaked in benzyl adenine (100 mg/L) for 6 h
T_8 = Water stress 20 days at pod development stage (65 to 85 DAS)
T_9 = T_8 + Seeds were soaked in benzyl adenine (100 mg/L) for 6 h

There were five (5) sub plot treatments applied in three growth stages viz., vegetative, pegging and pod development stages. These were as follows.

T_1 = Control T_2 = Water soaked for 6 h T_3 = BA soaked for 6 h
T_4 = Water deficit stress T_5 = BA with water deficit stress

Thus the first three treatments T_1 to T_3 were remain same in all three growth stages. While T_4 and T_5 (water deficit stress and BA soaked with water deficit stress) treatments applied at three growth stages viz., vegetative (20 to 40 DAS), pegging (45 to 65 DAS) and pod development (65 to 85 DAS). Thus total nine (9) different treatments were applied in the experiment.

One gram of groundnut leaf sample was transferred in a petri dish, and to this 10 ml distilled water was added and kept for one hour. Then the leaves were taken out, dried by blotting paper and weighed (turgid weight). After the leaf kept in oven at 80°C for 5 h and weighted until constant weight was obtained. After this RWC was estimated as per formula and expressed as per cent relative water content (Weatherley, 1962).

$$\text{Relative water content (\%) (RWC)} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}} \times 100$$

The number of plants was counted from each net plot and ten plants from each plot were collected randomly for estimation of physiological parameters viz., number of pods per plant, weight of pods per plant, pod yield, haulm yield, biological yield, harvest index, shelling percent etc. At the final harvest (120 d after sowing) pod yields were recorded. The calculation of harvest index (HI) and shelling outturn are given as following formula.

$$\text{HI} = \frac{\text{Total dry pod mass at final harvest}}{\text{Total dry biomass at final harvest}}$$

$$\text{Shelling out turn (\%)} = \frac{\text{Mass of kernels}}{\text{Mass f pods}} \times 100$$

RESULTS AND DISCUSSION

Relative water content (RWC)

The perusal of data (Figures 1 to 3) indicated that the cultivars were non significant at vegetative and pegging stages but at pod development stage the RWC was significantly higher in cv. GG-2 (79.12%).

At vegetative stage (Figure 1) mean treatment differences were found to be significant. Seed soaking treatment did not show any significant change under control conditions. On imposing drought, leaf RWC significantly reduced. However, BA soaked seed treatment followed by drought at vegetative stage (T_5) retained more RWC as compared to droughted plants (T_4) suggesting beneficial effect of BA under drought conditions. Similarly, at pegging stage (Figure 2) drought treatment (T_4) significantly reduced the RWC (59.94%) and the reduction was greater as compared to vegetative stage and at pod development stage (Figure 3). In contrast to this, leaves of groundnut cultivars had greater protection in BA soaked seed plants under drought (T_5) conditions.

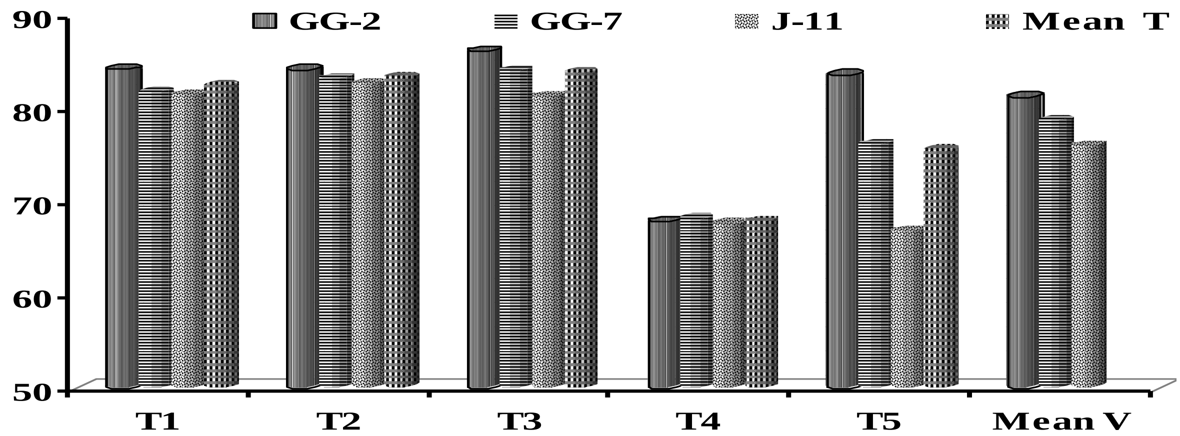

Figure 1. Influence of water deficit stress and benzyl adenine (BA) on relative water content (RWC) in leaves of groundnut at vegetative stage.
T_1 : Control, T_2: Water soaked, T_3 : BA soaked, T_4: Water stress, T_5: BA + water stress

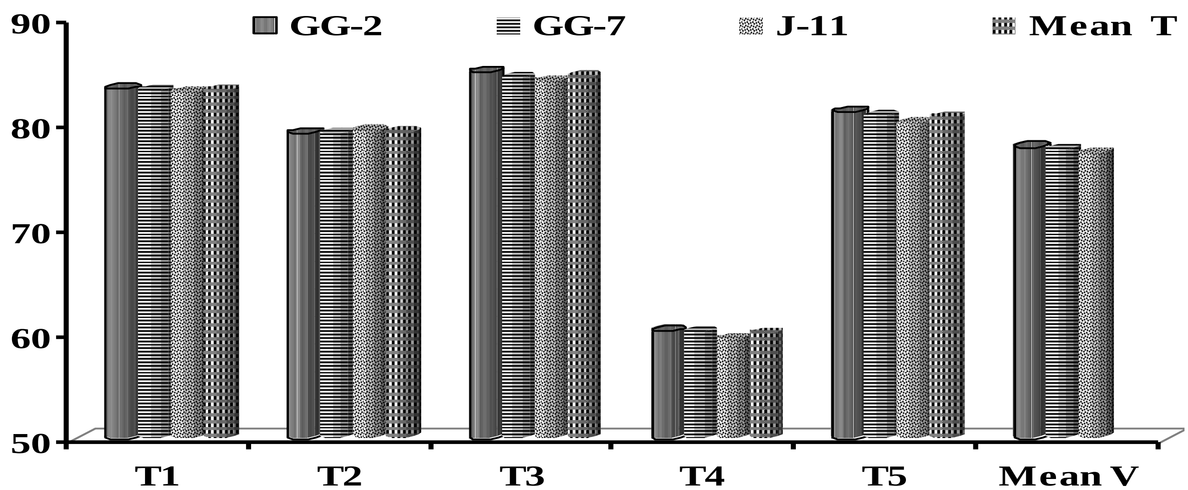

Figure 2. Influence of water deficit stress and benzyl adenine (BA) on relative water content (RWC) in leaves of groundnut at pegging stage.
T_1 : Control, T_2: Water soaked, T_3 : BA soaked, T_4: Water stress, T_5: BA + water stress

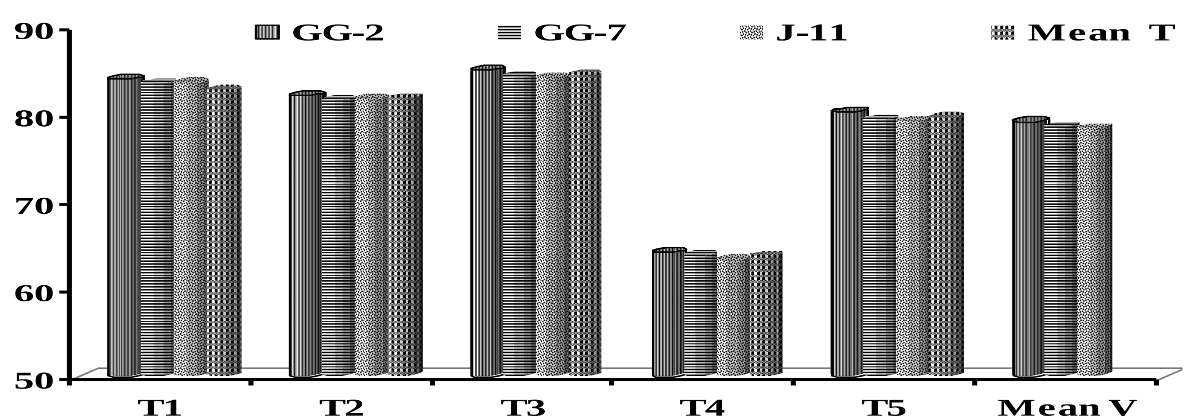

Figure 3. Influence of water deficit stress and benzyl adenine (BA) on relative water content (RWC) in leaves of groundnut at pod development stage T_1: Control, T_2: Water soaked, T_3: BA soaked, T_4: Water stress, T_5: BA + water stress.
T_1 : Control, T_2: Water soaked, T_3 : BA soaked, T_4: Water stress, T_5: BA + water stress

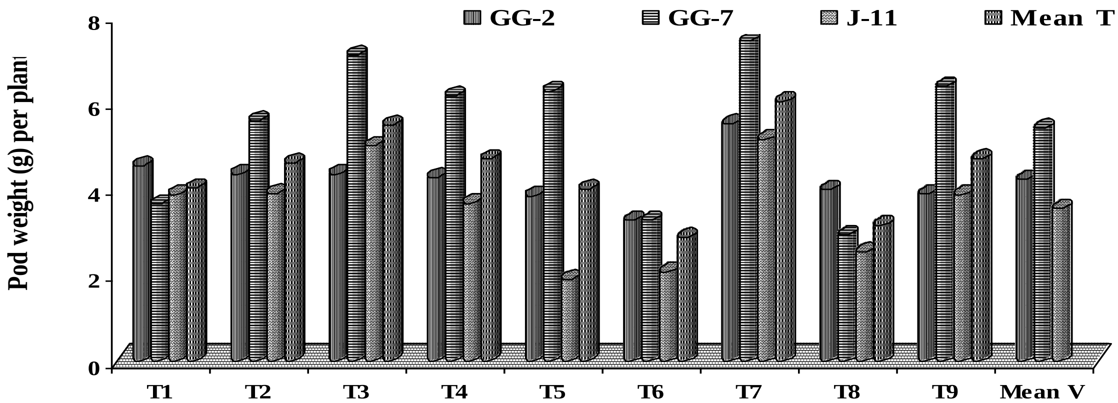

Figure 4. Influence of water deficit stress and benzyl adenine (BA) on; pod wt.g plant^{-1} of groundnut cultivars at different crop growth stages

T1, Control; T2, Water soaked; T3, BA soaked; T4, water stress at Vegetative stage; T5, BA + water stress at Vegetative stage T6, water stress at Pegging stage; T7, BA + water stress at Pegging stage; T8, water stress at Pod development stage T9, BA + water stress at Pod development stage

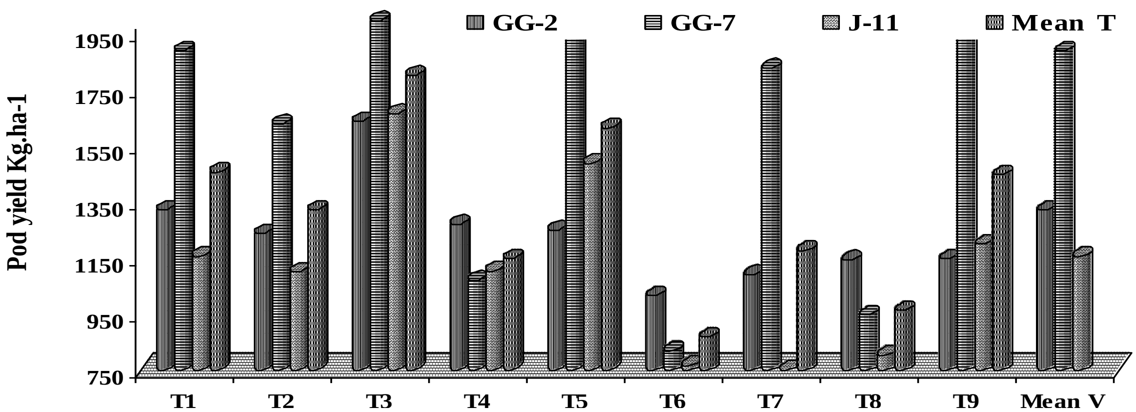

Figure 5. Influence of water deficit stress and benzyl adenine (BA) on; Pod yield Kg.ha^{-1} of groundnut cultivars at different crop growth stages.

T_1, Control; T_2, Water soaked; T_3, BA soaked; T_4, water stress at Vegetative stage; T_5, BA + water stress at Vegetative stage T_6, water stress at Pegging stage; T_7, BA + water stress at Pegging stage; T_8, water stress at Pod development stage T_9, BA + water stress at Pod development stage

Interaction effect of cultivars and treatments were found to be significant at vegetative stage. Imposition of drought at vegetative stage (T_4) significantly reduced the RWC. Benzyl adenine seed soaking treatment followed by drought at vegetative stage (T_5) had significantly retained more RWC in all the cultivars. Cultivar GG-2 had greater protection as compared to cv. GG-7 and Cv. J-11.

Many reports showed that drought reduced the leaf RWC in groundnut (Kramer, 1993; Vakharia et al., 1993, 1999; Madhusudhan et al., 2002; Qualimbo, 2004; Reddy et al., 2003; Dhruve, 2011) reported that BA soaked seed treatment followed by water deficit stressed plants had more RWC in groundnut at all critical growth stages.

Pod weight per plant

Among the cultivars, the highest pod weight per plant was recorded in cv. GG-7 (Figure 4) and it was declined under drought conditions at all crop growth stages. However, BA soaked seed treatment resulted significantly higher pod weight per plant under drought conditions at all growth stages as compared to drought treatment alone. Reduced available moisture severely affects the peg penetration which leads to reduced yield. The pod yield of groundnut decreased under water stress conditions (Patil and Gangavane, 1990; Kandoliya, 1993; Reddy et al., 2003).

Pod yield (kg/ha)

At vegetative stage highest pod yield (1616 kg.ha^{-1}) was recorded in BA soaked seeds followed by drought conditions (Figure 5), which was about 44% higher than the compared to untreated seed at vegetative stage (T_4). This was true at all crop growth stage but the magnitude of increase was different. Significantly highest pod yield

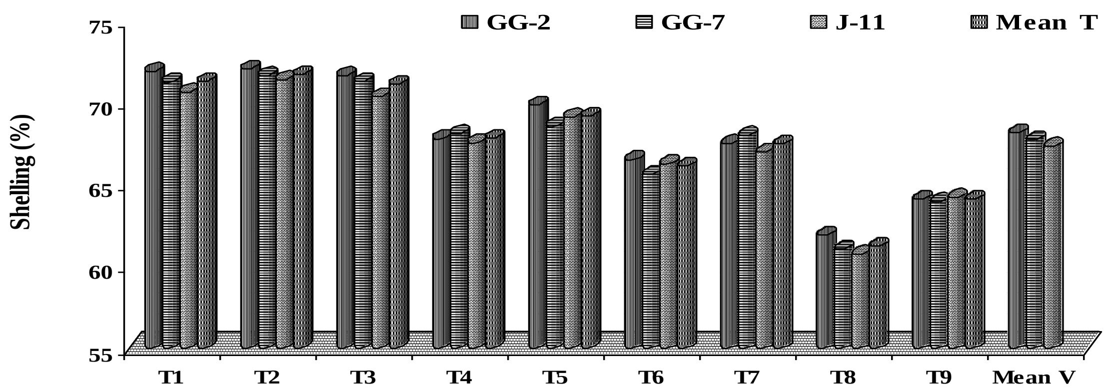

Figure 6. Influence of water deficit stress and benzyl adenine (BA) on; Shelling (%) of groundnut cultivars at different crop growth stages.
T_1, Control; T_2, Water soaked; T_3, BA soaked; T_4, water stress at Vegetative stage; T_5, BA + water stress at Vegetative stage T_6, water stress at Pegging stage; T_7, BA + water stress at Pegging stage; T_8, water stress at Pod development stage T_9, BA + water stress at Pod development stage.

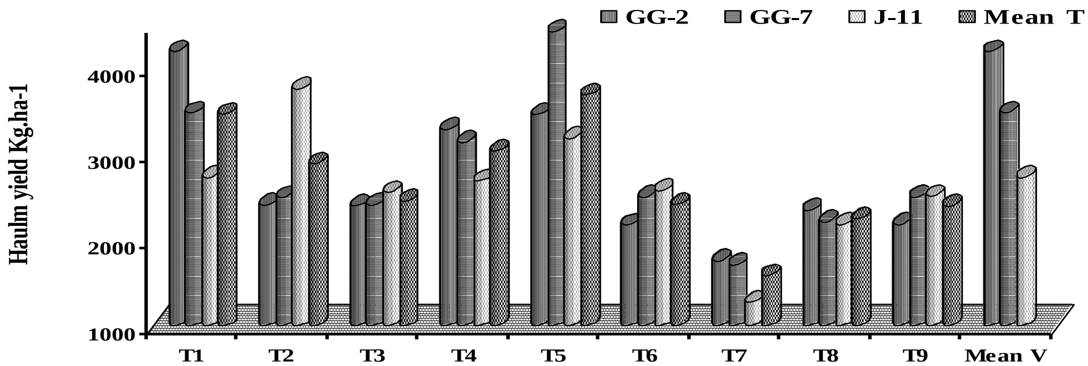

Figure 7. Influence of water deficit stress and benzyl adenine (BA) on haulm yield (Kg.ha^{-1}) of groundnut cultivars at different crop growth stages.
T_1, Control; T_2, Water soaked; T_3, BA soaked; T_4, water stress at Vegetative stage; T_5, BA + water stress at Vegetative stage T_6, water stress at Pegging stage; T_7, BA + water stress at Pegging stage; T_8, water stress at Pod development stage T_9, BA + water stress at Pod development stage

was recorded in cv. GG-7 followed by cv. GG-2. On imposing drought, the yield was declined at all growth stages. However, the pod yield was higher in BA soaked seed followed by drought treatments at all crop growth stages. The highest pod yield was recorded in cv. GG-7 at vegetative stage in BA soaked seed treatment followed by drought conditions. The water deficit stress at vegetative phase resulted increased in 100 kernel weight (Nautiyal et al., 1991). Vakharia et al. (1998) revealed that maximum reduction occurred in the pod yield when drought imposed at pegging stage in groundnut. The beneficial effect of BA on pod yield was reported by Shivakumar and Virendranth (2000), Reddy et al. (2003) and Dhruve (2007). They have also stated that water stress decreased the pod yield but the reduction was less with BA than the untreated plant.

Shelling percent

Among the cultivars the shelling percent was significantly higher in cv. GG-2 (Figure 6). The shelling out turn was higher in normal irrigated and with seed soaking treatments. The shelling percent was reduced under drought conditions at all crop growth stages. The BA soaked seed followed by drought treatments had higher yield as compared to untreated plants. Narasimham et al. (1977) revealed that 75% depletion of available soil moisture reduced the shelling percentage of groundnut pods as compared to that of 25% moisture depletion level. The shelling percent decreased under water deficit stress conditions (Kandoliya, 1993; Vakharia, 2001).

Haulm yield and biological yield

Haulm yield was varied between 2716 to 4182 kg.ha^{-1} among the cultivars and the same found to be non significant (Figure 7). On imposing drought conditions the greater reduction in haulm yield was recorded at pegging stage that is, T_6 (2447 kg.ha^{-1}). However, BA soaked

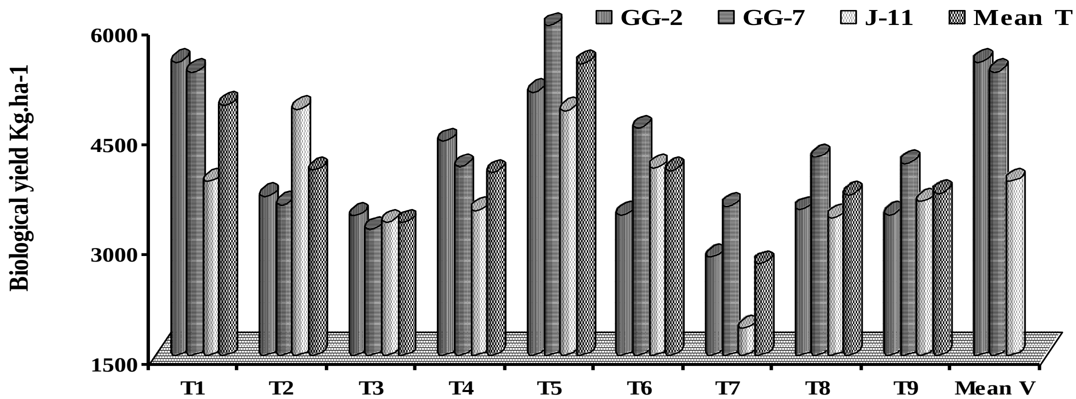

Figure 8. Influence of water deficit stress and benzyl adenine (BA) on Biological yield (Kg.ha^{-1}) of groundnut cultivars at different crop growth stages.
T_1, Control; **T_2,** Water soaked; **T_3,** BA soaked; **T_4**, water stress at Vegetative stage; **T_5**, BA + water stress at Vegetative stage **T_6**, water stress at Pegging stage; **T_7,** BA + water stress at Pegging stage; **T_8**, water stress at Pod development stage **T_9**, BA + water stress at Pod development stage

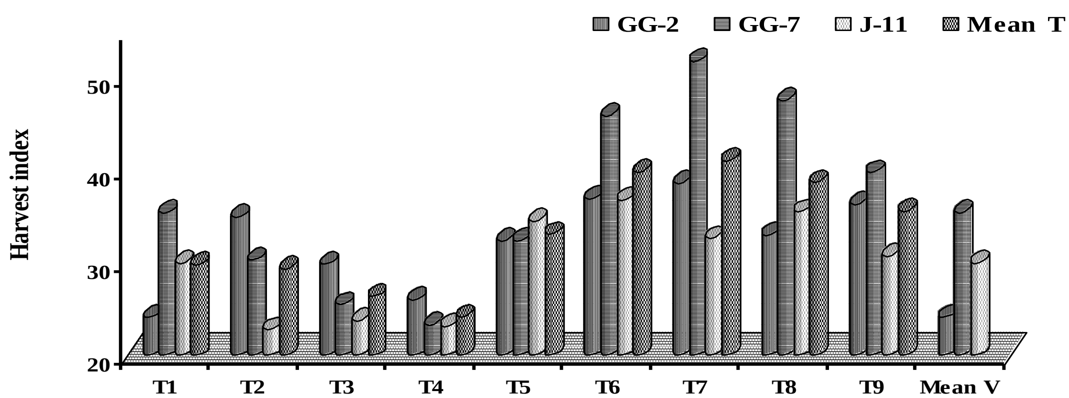

Figure 9. Influence of water deficit stress and benzyl adenine (BA) on Harvest index of groundnut cultivars at different crop growth stages.
T_1, Control; T_2, Water soaked; T_3, BA soaked; T_4, water stress at Vegetative stage; T_5, BA + water stress at Vegetative stage T_6, water stress at Pegging stage; T_7, BA + water stress at Pegging stage; T_8, water stress at Pod development stage T_9, BA + water stress at Pod development stage.

seeds treatment under drought conditions resulted into negative effect on haulm yield at respective growth stages. The drought inhibits the leaf expansion in relative turgidity, which resulted in poor yield and possibly poor haulm yield (Vivekandan and Gunasena, 1976; Kandoliya, 1993; Vakharia, 2001; Dhruve, 2007). The maximum haulm yield and biological yield (Figure 8) was recorded in cv. GG-2. The HY and BY were declined under drought conditions at all crop growth stages. The highest HY and BY was observed in BA soaked seed followed by drought conditions at vegetative stage.

Harvest index

Among the treatments the maximum HI (Figure 9) was recorded with water soaked seed (T_2) as compared to BA soaked seeds (T_3) followed by control (T_1). On imposing drought the HI reduced at all critical growth stages. In case of BA soaked seeds treatments the HI found to be at par among the growth stages under drought conditions. However the HI was higher in BA soaked seeds treatment as compared to unsoaked seeds treatment at all growth stages (Figure 9). Toprope et al. (2004) reported that HI was the critical measure of water use efficiency under water deficit stress conditions. Greater HI was observed at pegging and pod development stage under drought conditions. Benzyl adenine soaked seed treatment alone reduced the HI as compared to control, while, BA followed by drought at vegetative stage significantly improved the HI.

The data revealed that cultivars, treatments and its interactions were found significant for harvest index (Figure 9). The minimum HI was recorded in Cv. GG-2

(24.08) and the same was maximum in Cv. GG-7 (35.42) followed by J-11 (29.94).

Thus, it could infer from the aforementioned study that BA seed treatment improves the metabolic activity and drought tolerance capacity of the cultivars during water deficit stress conditions. Benzyl adenine soaking seed treatment significantly improved the pod yield, haulm yield and biological yield under drought conditions and greater positive effect of BA was recorded under drought conditions at vegetative stage followed by pod development and pegging stage.

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