Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5576

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (4):** 1289-1294 (2017)

Research Article

OPEN ACCESS

Influence of Stress Mitigating Compounds on Biophysical Parameters & Yield and Yield Attributes under Drought Conditions in Groundnut (*Arachis hypogea* L.)

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Received: 22.07.2017 | Revised: 4.08.2017 | Accepted: 5.08.2017

ABSTRACT

A Field experiment was conducted during the year 2014-15 at Agriculture College Farm, Raichur to investigate the appropriate technology to overcome the ill effects of water stress on growth and development of groundnut crop. Water stress plots were treated with various stress mitigating compounds, significantly higher pod yield was recorded with application of Triacontanol @2.0 ml/l (28.3 q/ha) followed by KCl @ 2.5% (26.9 q/ha) Methanol (2 %) (26.6 q/ha). Biophysical parameters like transpiration rate were shown maximum in Triacontanol and minimum diffusive resistance was seen in same treatment. Whereas, among the stressed plot Relative Water Content (RWC) was found more in Triacontanol followed by KCl (76.6%). At 45 DAS, Finally yield deciding parameter in photosynthetic rate was showed significant differences between the treatments. Photosynthetic rate (31.87µ mol CO_2 m^{-2} s-^{1}) was higher in unstressed plot wherein continuous irrigation without stress. Among the different stress mitigating compounds foliar application of Triacontanol has recorded significantly higher photosynthetic rate (30.13µ mol CO_2 m^{-2} s^{-1}) followed by Nitrobenzene (30.03µ mol CO_2 m^{-2} s^{-1}) Methanol (28.33 µ mol CO_2 m^{-2} s^{-1}) Salicylic acid, Kaoline and lower in stressed plots. Finally the yield components No. of Pods plant^{-1}, Pod weight (g), pod yield (q ha^{-1}) and harvest Index(%) were studied and maximum yield was recorded in the foliar spray of Triacontanol (28.3 q ha^{-1}) followed by KCl (26.9q ha^{-1}) and Methanol (6%) (26.6 q ha^{-1}).

Key words: *Diffusive resistance, Groundnut, Kaoline, Pod yield, RWC. Stress mitigation, Photosynthetic rate and Transpiration rate.*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important food legume and oilseed crop. It is cultivated predominantly in tropics and subtropics. Drought is one of the most universal and significant environmental stress affecting plant growth and productivity worldwide. Therefore, understanding crop response to this stress is the basis for regulating crops appropriately and achieving agricultural water savings. There are significant differences in the tolerance of plants to drought stress depending upon intensity and duration of stress, plant species and the stage of development[14].

Cite this article: Harish, M. and Patil, R.P., Influence of Stress Mitigating Compounds on Biophysical Parameters & Yield and Yield Attributes under Drought Conditions in Groundnut (*Arachis hypogea* L.), *Int. J. Pure App. Biosci.* **5(4):** 1289-1294 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5576

The response of a crop to water stress varies with crop species, crop growth stage, soil type, environment and season. Drought stress causes a series of physiological, biochemical and morphological responses of crops, which finally results in low yield of green gram[9].

Groundnut has C_3 pathway of photosynthesis. The production potential of groundnut is low, the actual yield achieved is still far below their minimum potential. Depending upon magnitude and duration of stress situation, the mechanism adapted by plants to drought stress are different. Plants have thus developed specific escape, avoidance and tolerance mechanisms to combat these different stress situations. Among the various abiotic stresses, drought is the major factor that limits crop productivity worldwide[15]. In water-limiting environments, the decrease on growth and productivity results of osmotic effect, and different plant species appears to activate various physiological and biochemical mechanisms to endure the stress[11]. Osmotic adjustment by organic solutes accumulation, reduction of photosynthetic activity[15] and changes on antioxidative metabolism are typical physiological and biochemical responses to water stress[8].

During rabi/summer months groundnut crop suffers either due to intermittent drought or permanent drought. Most of the stress mitigating research has been done in other crops. The available stress mitigating compounds in market have proven as stress mitigating compounds. With this background the experiment has been planned to find out the appropriate technology to mitigate the ill effects of water stress.

MATERIAL AND METHODS

Field experiment was conducted at Agricultural College Farm, Raichur (16° 12' N; 77° 20' E, 389 m altitude) during 2014-15 to evaluate stress mitigating compounds for drought in Groundnut crop during summer months. The field was ploughed and harrowed to get fine tilth. At basal, 25- 20-14 kg N-P_2O_5-K_2O/ha was applied in the form of urea, Diammonium phosphate and Muriate of Potash. The popular variety of the region Kadari -9 was selected for the study. The crop was sown on 4th December, 2014. Gypsum @ 500 kg/ha was applied at 45 days after sowing before earthing up. The treatments consist of foliar application of KCL @1.0 %, fatty alcohol @ 2.0 ml/l, alachlor @ 20 ppm, Methanol @ 2%, Kaoline @ 6%, Atrazine @ 100 ppm, Nitrobenzene @ 20 ppm , salicylic acid @ 500 ppm, CCC @ 100 ppm and water alone was compared with unstressed plants (irrigation interval 10 days) and stress imposed plants (irrigation interval 20 days). Experiment was laid out in randomized complete block design with three replications. Stress management treatments were imposed during December month. During early part of the crop period sufficient moisture was maintained. Stress was imposed on 30 days after sowing by withholding water upto 20 days except in unstressed plots wherein irrigation water provided once in 10 days.

Relative water content (RWC) was estimated by as per the procedure of [1]. It is the ratio of actual moisture content and turgid weight of leaves. Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1}) was measured by using IRGA (infra red gas analyzer,TPS-2) during bright sunlight hours. Diffusive resistance (s cm^{-1}), leaf temperature and transpiration rate (m mol H_2O m^{-2} s^{-1}) were measured by using leaf porometer. Leaf resistance (s cm^{-1}) was measured by placing sensor head on the upper surface of the topmost fully expanded leaf. Pod yield (q ha^{-1}) was estimated. The experimental data were analysed statistically by following Fischer's method of analysis of variance.

RESULTS AND DISCUSSION

Biophysical parameters like diffusive resistance, transpiration rate and photosynthetic rate were significantly influenced by stress and foliar application of stress mitigating compounds. The relative water content (RWC) is another important parameter considered in determining the drought resistance in the crops (Table 1).

However, RWC was found higher in foliar spray of triacontanol (2.0 ml/l) compared to other treatments followed by KCl (1 %), nitrobenzene (20 ppm), kaoline (6 %) and methanol (2 %). Whereas, stressed plot had significantly lower relative water content over all other treatments. These results are in conformity with the findings of Hunshal *et al*[4].

The maximum transpiration rate was recorded in normal irrigated plot which was significantly superior over rest of the treatments (Table 2). Among stress mitigating compounds foliar application of Triacontanol @ 2.0 ml/l (9.07 m mol H_2O m^{-2} s^{-1}) recorded significantly higher transpiration rate (11.70 m mol H_2O m^{-2} s^{-1}) followed by nitrobenzene, kaoline, salicylic acid, Atrazine, CCC, KCl and methanol.. At harvest, control treatment with irrigation at 10 days continued to maintain significantly higher transpiration rate. Relative water content was found higher in foliar spray of Triacontanol @ 2.0 ml/l followed by KCl @1 % and nitrobenzene @20 ppm. The yield and quality attributes showed significantly higher values in normal irrigation unstressed plants. Significantly higher number of pods per plant was recorded with foliar application of Triacontanol @ 2.0 ml/l followed by Kaoline @6 %, KCl @1 % and salicylic acid @500 ppm as compared to other stress mitigating treatment lowest in stressed plot. The pod weight per plant was significantly higher in foliar application of Triacontanol (8.5 g) followed by KCl, Methanol and Kaoline as compared to other stress mitigating treatments.

Photosynthetic rate increased from 45 to 85 DAS and differed significantly between the different stress mitigating treatments and at harvest it was noticed that photosynthetic rate was decreased (Table 3). The foliar application of triacontanol (2.0 ml/l) recorded significantly higher photosynthetic rate followed by foliar spray of nitrobenzene (20 ppm), methanol (2 %), salicylic acid (500 ppm), kaoline (6 %) and KCl (1 %) as compared to other treatments. However, significantly lower photosynthetic rate was recorded in stressed plot. These results are in the line with the findings of [5] reported that the photosynthetic rate and stomatal conductance decreased significantly in all cultivars subjected/ submitted to water deficit. In control plants of the tolerant cultivars (SP83-2847 and CTC15) the photosynthetic rate was higher than in the sensitive cultivar (SP86-155). And also [2] reported that water stress significantly ($p < 0.05$) decreased all the photosynthesis parameters, i.e. net photosynthetic rate (Pn), stomatal conductance (gs), internal carbon dioxide concentration (Ci), water use efficiency (WUE) and transpiration rate. Similarly [2] investigated in sunflower that the highest photosynthetic rate in KBSH-53 closely followed by KBSH-44 and lowest in Mordern.

Biophysical parameters like diffusive resistance and transpiration rate showed significant differences between the treatments. Maximum values for diffusive resistance was found in the stressed treatment, while the normal irrigation recorded minimum values. Significantly lower diffusive resistance was recorded in control and higher in all stressed plants. Triacontanol had the higher diffusive resistance to all other treatments except nitrobenzene, methanol and Kaoline but were on par with each other. At harvest, stress plot with irrigation at 20 days interval continued to maintain significantly higher diffusive resistance However, significantly lower diffusive resistance was recorded in normal irrigation plot compared to all other stress mitigating treatments (Table 4).

In the present investigation, it is observed that Pod yield (q ha^{-1}**)** was significantly higher in unstressed irrigation plot (29.6 q ha^{-1}) and lowest in stressed plants (Table 5). Among stress mitigating compounds Triacontanol has recorded significantly higher pod yield (28.3 q ha^{-1}) followed by KCl (26.9 q ha^{-1}), methanol (26.6 q ha^{-1}), kaoline (25.9 q ha^{-1}) and nitrobenzene (23.9 q ha^{-1}). Shelling percentage was higher in normal irrigated plots (73.58 %), Triacontanol @ 2.0 ml/l (71.83 %) and CCC @100 ppm. Significantly lower shelling percentage was observed in stressed plot (49.9 %). **S**ignificantly higher harvest index (51.95 %) recorded in unstressed plots. Among the stress mitigating compounds foliar application of Triacontanol @ 2 ml/l recorded significantly improved harvest index (51.44 %) followed by kaoline (50.2%) and KCl (1%) (49.9 %) and lowest in stress imposed plot (43.4 %). These results are in confirmity with the findings of [12] and [13] reported that maximum cane yield was found with the foliar spray of kaoline (6 %) followed by soil application of K_2O and foliar spray of KCl (3 %). The higher cane yield was attributed to the conservation of soil moisture and as such the nutrient uptake by the crop was more and this lead to the vigorous growth of the crop. Similarly, [7] , [6] and [10]. The results inferred that significant reduction of groundnut productivity by stress and it can be minimized by foliar application of stress mitigating compounds. Triacontanol @ 2.0 ml/l, kaoline @ 6 % and methanol @ 2 % were found effective to overcome stress in groundnut during summer months.

Table 1: Relative water content (RWC, %) of groundnut at different growth stages as influenced by stress mitigating compounds

Treatments	Days after sowing			At harvest
	45	65	85	
T_1: Control*	79.3	82.1	79.0	73.3
T_2: Stress plot**	64.2	68.2	70.7	66.6
T_3: T_2+Foliar application of KCl @ 1.0 %	73.4	80.6	76.3	68.5
T_4=T_2+ Foliar application of Triacontanol @ 2.0 ml/l	78.0	81.7	76.8	68.9
T_5 = T_2+ Foliar application of Alachlor @ 20 ppm	66.2	68.4	71.2	67.0
T_6 = T_2+Foliar application of Methanol @ 2 %	72.3	74.2	75.6	67.2
T_7 = T_2+ Foliar application of Kaoline @ 6 %	72.7	76.7	75.5	67.7
T_8 = T_2+ Foliar application of Atrazine @100 ppm	66.8	75.6	74.4	67.0
T_9 =T_2+ Foliar application of Nitrobenzene @ 20 ppm	76.7	79.4	76.2	66.9
T_{10}=T_2+ Foliar application of Salicylic acid @500 ppm	71.2	74.7	75.3	68.2
T_{11} = T_2+ Foliar application of CCC @100 ppm	71.5	77.4	75.6	67.9
T_{12} = T_2+ Foliar application of water	66.3	68.9	71.8	66.8
S.Em.±	4.0	4.5	1.8	1.4
C.D. at 5 %	11.7	13.2	5.2	4.1

* Crop was irrigated at 10 days interval; ** Crop was irrigated at 20 days interval

Table 2: Transpiration rate (m mol H_2O $m^{-2}s^{-1}$) of groundnut at different growth stages as influenced by stress mitigating compounds

Treatments	Days after sowing			At harvest
	45	65	85	
T_1: Control*	12.98	11.20	10.53	9.50
T_2: Stress plot**	10.07	9.28	8.77	7.83
T_3: T_2+Foliar application of KCl @ 1.0 %	11.02	10.56	9.28	7.75
T_4=T_2+ Foliar application of Triacontanol @ 2.0 ml/l	11.70	11.17	10.73	9.07
T_5 = T_2+ Foliar application of Alachlor @ 20 ppm	10.67	10.12	8.85	7.73
T_6 = T_2+Foliar application of Methanol @ 2 %	10.90	10.60	9.63	7.30
T_7 = T_2+ Foliar application of Kaoline @ 6 %	11.10	10.47	10.47	8.33
T_8 = T_2+ Foliar application of Atrazine @100 ppm	11.03	10.63	10.23	7.80
T_9 =T_2+ Foliar application of Nitrobenzene @ 20 ppm	11.50	11.02	10.34	8.53
T_{10}=T_2+ Foliar application of Salicylic acid @500 ppm	11.32	10.23	10.10	8.17
T_{11} = T_2+ Foliar application of CCC @100 ppm	11.03	10.97	10.03	8.33
T_{12} = T_2+ Foliar application of water	10.17	10.30	9.07	7.82
S.Em.±	0.29	0.36	0.56	0.38
C.D. at 5 %	1.01	1.04	1.65	1.12

* Crop was irrigated at 10 days interval; ** Crop was irrigated at 20 days interval

Table 3: Photosynthetic rate (μ mol CO_2 $m^{-2}s^{-1}$) of groundnut at different growth stages as influenced by stress mitigating compounds

Treatments	Days after sowing 45	65	85	At harvest
T_1: Control*	27.94	31.88	37.07	34.50
T_2: Stress plot**	22.93	25.57	29.40	27.72
T_3: T_2+Foliar application of KCl @ 1.0 %	27.69	29.97	32.62	32.00
T_4=T_2+ Foliar application of Triacontanol @ 2.0 ml/l	27.80	30.13	33.97	31.57
T_5 = T_2+ Foliar application of Alachlor @ 20 ppm	25.27	26.52	31.62	28.43
T_6 = T_2+Foliar application of Methanol @ 2 %	27.60	28.33	32.27	31.77
T_7 = T_2+ Foliar application of Kaoline @ 6 %	27.33	27.90	30.93	30.23
T_8 = T_2+ Foliar application of Atrazine @100 ppm	25.32	26.02	31.21	28.37
T_9 =T_2+ Foliar application of Nitrobenzene @ 20 ppm	27.70	30.03	32.67	31.43
T_{10}=T_2+ Foliar application of Salicylic acid @500 ppm	27.37	29.07	32.33	30.60
T_{11} = T_2+ Foliar application of CCC @100 ppm	27.33	29.80	31.67	31.00
T_{12} = T_2+ Foliar application of water	25.27	26.73	31.10	28.23
S.Em.±	0.78	1.15	0.78	1.07
C.D. at 5 %	2.28	3.35	2.29	3.13

* Crop was irrigated at 10 days interval; ** Crop was irrigated at 20 days interval

Table 4: Diffusive resistance (s cm^{-1}) of groundnut at different growth stages as influenced by stress mitigating compounds

Treatments	Days after sowing 45	65	85	At harvest
T_1: Control*	127.8	136.1	233.3	151.8
T_2: Stress plot**	262.6	291.7	370.1	296.1
T_3: T_2+Foliar application of KCl @ 1.0 %	205.1	211.9	292.6	247.3
T_4=T_2+ Foliar application of Triacontanol @ 2.0 ml/l	246.2	247.3	339.9	270.1
T_5 = T_2+ Foliar application of Alachlor @ 20 ppm	147.8	163.5	259.5	231.7
T_6 = T_2+Foliar application of Methanol @ 2 %	218.4	234.9	317.8	226.8
T_7 = T_2+ Foliar application of Kaoline @ 6 %	219.0	228.5	319.6	264.9
T_8 = T_2+ Foliar application of Atrazine @100 ppm	176.5	175.4	263.5	273.8
T_9 =T_2+ Foliar application of Nitrobenzene @ 20 ppm	222.1	243.3	323.1	270.1
T_{10}=T_2+ Foliar application of Salicylic acid @500 ppm	192.7	197.9	286.5	201.9
T_{11} = T_2+ Foliar application of CCC @100 ppm	182.2	193.5	279.9	226.3
T_{12} = T_2+ Foliar application of water	137.8	145.1	244.3	236.0
S.Em.±	9.9	9.9	7.6	8.3
C.D. at 5 %	29.0	28.9	22.2	24.9

* Crop was irrigated at 10 days interval; ** Crop was irrigated at 20 days interval

Table 5: Yield and yield components of groundnut as influenced by stress mitigating compounds

Treatment	Pods $plant^{-1}$	Pod weight (g $plant^{-1}$)	pod yield (q ha^{-1})	Pegs to pod ratio	Shelling Percentage (%)	HI (%)
T_1: Control*	19.4	8.9	29.6	0.62	73.6	52.0
T_2: Stress plot**	14.3	6.0	19.9	0.96	50.0	43.4
T_3: T_2+Foliar application of KCl @ 1.0 %	18.6	8.1	26.9	0.81	67.2	49.9
T_4=T_2+ Foliar application of Triacontanol @ 2.0 ml/l	19.3	8.5	28.3	0.72	71.8	51.4
T_5 = T_2+ Foliar application of Alachlor @ 20 ppm	15.9	6.4	21.3	0.80	68.2	45.5
T_6 = T_2+Foliar application of Methanol @ 2 %	18.9	8.0	26.6	0.82	67.0	48.8
T_7 = T_2+ Foliar application of Kaoline @6 %	19.1	7.8	25.9	0.74	68.0	50.2
T_8 = T_2+ Foliar application of Atrazine @100 ppm	15.3	6.5	21.6	0.68	65.7	43.4
T_9 =T_2+ Foliar application of Nitrobenzene @20 ppm	19.0	7.2	23.9	0.86	70.1	48.9
T_{10}=T_2+ Foliar application of Salicylic acid @500 ppm	18.7	6.9	22.9	0.71	67.5	47.9
T_{11} = T_2+ Foliar application of CCC @100 ppm	18.6	6.8	22.6	0.78	70.4	48.0
T_{12} = T_2+ Foliar application of water	15.8	7.0	23.3	0.86	69.1	47.0
S.Em.±	0.76	0.39	1.68	0.12	1.2	0.5
C.D. at 5 %	2.21	1.13	4.91	NS	3.5	1.6

* Crop was irrigated at 10 days interval; ** Crop was irrigated at 20 days interval

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