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Growth, yield and economics of groundnut (*Arachis hypogaea* L.) as influenced by foliar sprays of stress mitigating compounds

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Abstract
Field experiment was conducted during *summer* 2020- 21 and 2021-22 at Agricultural College Farm, Raichur to know the effect of different stress mitigating compounds on morpho-physiological characters, yield and yield components in groundnut under soil moisture stress. Experiment was laid out in randomized block design with three replications. The data indicated that plant height, leaf area per plant and total dry matter per plant was significantly lower in water stressed treatments compared to all other treatments. Pod yield of groundnut was significantly higher in normal irrigation (30.7 q ha^{-1}) over water stressed treatments (21.8 q ha^{-1}). Among the stress mitigating treatments however maximum pod yield was obtained in the treatment foliar application of triacontanol @ 2.0 ml/l (29.4 q ha^{-1}) followed by KCl @ 1.0 percent (27.9 q ha^{-1}), kaoline @ 6 percent (27.3 q ha^{-1}) and methyl jasmonates @ 20 ppm (26.0 q ha^{-1}). However Economic analysis of different stress mitigating treatments in groundnut crop revealed that foliar application of kaoline (6%) had higher cost of cultivation and triacontanol (2 ml/l) had higher gross returns, net returns and B:C ratio followed by KCl (1%) and methanol (2%) respectively. However, lower net returns and B: C ratio was obtained with stressed plot.

Keywords: Groundnut, moisture stress, triacontanol, stress mitigating compounds, yield

Introduction
Groundnut (*Arachis hypogaea* L.) is an important food legume and oilseed crop. It is cultivated predominantly in tropics and subtropics. It is the 13th most important food crop of the world. It is the world's 4th most important source of edible oil and 3rd most important source of vegetable protein. Groundnut seeds contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrate (20%). It is known as king of oilseed crop and is believed to be native of Brazil (South America). It was introduced to India during early sixteenth century. It is a self pollinated crop belongs to the family leguminosae (*A. hypogaea)* and sub family Papilionaceae.
Drought is one of the most universal (for rainfed situations / drought prone) and significant environmental stress affecting plant growth and productivity worldwide (Valliyodan and Nguyen, 2006) [13]. 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 (Singh *et al*., 2012) [10]. 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 (Malik *et al*., 2006) [3].
Work pertaining to drought tolerance and the avenues to overcome water stress through physiological approaches in groundnut are very meager. Understanding of the mechanisms involved in this matter help desire solution to the associated problems effectively. With this background present investigation was undertaken to know different treatments on morphological, yield attributes in groundnut.

Material and Methods
The experiment was conducted during *summer* 2020- 21 and 2021-22 at Agricultural College Farm, Raichur. University of Agricultural Sciences, Raichur. Geographically, the station is situated in the North-Eastern dry zone (Zone- 2) of Karnataka State at 16° 15' North latitude and 77° 20' East longitude and at an altitude of 389 meter above mean sea level.

Soils of the experiment were red soil with Ph 7.76. The experiment was laid out in randomized block design with three replications. Treatments consists of foliar application in water stressed plots with KCl @ 1 percent; Triacontanol @ 2.0 ml/l; Methanol @ 2 percent; Kaoline @ 6 percent; Methyl Jasmonates (0.5 ppm); Urea (2%); Salicylic acid @ 500 ppm and Brassinosteroids (1 ppm). These treatments are compared with unstressed (Control) and stressed plots without spraying of stress mitigating compounds. Variety kadiri-9 was selected for the study. Seeds are sown in 30 cm rows at a distance of 10 cm. Periodic observation of growth and physiological changes were recorded. The research data was statistically analyzed for interpretation.

Results and Discussion

The data on morpho-physiological parameters *viz*., plant height, leaf area and total dry matter production are presented in Table 1. All the morpho-physiological parameters differed significantly with foliar spray of different stress mitigating compounds.

Significant differences between the treatments were noticed in plant height. Among the treatments, foliar application of triacontanol @ 2.0 ml/l registered significantly higher plant height compared to other treatments followed by foliar spray of nitrobenzene @ 20 ppm and methanol @ 2 percent. Significantly lower plant height was recorded in water stressed treatment. However, highest plant height was observed in normal irrigation. This may be due triacontanol can exerts stimulatory effects equally well at different growth stages on all growth attributes, photosynthetic pigments, leaf nutrients, protein and carbohydrate contents, quality and productivity of plants yield Singh *et al*., 2012 [10]. Though, plant height is basically a genetically controlled character, it is being influenced by environmental conditions and management practices. Present results are in conformity with the findings of Aboelill *et al*., 2012, Sinha, 1978, Subramaniam *et al*., 1991, Naik *et al*., 1993 and Patil *et al*., 2009 [1, 11, 12, 7, 8] who opined that increase in plant height in sugarcane was due to reflection action of antitranspirants thereby leading to higher retention of moisture and the regulation of the stomata.

Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. Among several morphological characters associated with yield, maintenance of functional leaf and higher leaf area, particularly during later growth stages seem to be most important. In the present study, the data on leaf area per plant indicated that it was more in control at all the growth stages. Treatments differed significantly at all the stages and it increased continuously from 45 DAS to harvest. At 45 DAS, control had maximum leaf area which was significantly higher over all other treatments except triacontanol (2.0 ml/l) and nitrobenzene (20 ppm). Whereas, lowest leaf area was recorded in stressed plot. These results are in conformity with the findings of Mukundarao *et al.* (2002) [5] and Mirabad *et al*. (2013) [4] reported that increasing irrigation levels increased leaf area of Cantaloupe (*Cucumis melo* L.) as compared to deficit irrigation.

The total dry matter produced is an indication of the overall efficiency of resources utilization and better light interception. In general total dry matter production increased from 45 DAS to harvest. In this study, among various treatments, triacontanol (2.0 ml/l) was shown to have maximum total dry matter and was significantly superior over stressed plot, followed by foliar application of KCl (1%), kaoline (6%), nitrobenzene (20 ppm) and CCC (100 ppm). At 65 DAS, stressed plot had significantly lower total dry matter. At 85 DAS, control (normal irrigation) continued to maintain significantly higher total dry matter over all other treatments. Similar results were also obtained by Patil *et al*. (2009) [8] reported that increased succulence helped to retain moisture which mitigated drought in sugarcane and also due to reflection action of antitranspirants thereby leading to higher retention of moisture and the regulation of the stomata.

The results showed that significantly higher numbers of pods per plant were recorded with foliar application triacontanol (2.0 ml/l) compared to other treatments followed by nitrobenzene (20 ppm), kaoline (6%), methanol (2%), KCl (1%) and salicylic acid (500 ppm). However, no significant differences were observed between alachlor (20 ppm), atrazine (100 ppm) and water spray treatments. Significantly a least number of pods per plant were observed in stressed plot compared to all other treatments. These findings are in conformity with the reports of Collinson *et al.* (1996) [2] reported a significant reduction in pod number per plant, harvest index (HI) and final yield due to drought.

In the present study, among the stress mitigating treatments triacontanol (2.0 ml/l) recorded significantly more pod weight per plant compared to other treatments followed by KCl (1%), methanol (2%) and kaoline (6%). However, no significant differences were observed between alachlor (20 ppm), atrazine (100 ppm), CCC (100 ppm), and salicylic acid (500 ppm) treatments. These findings are in conformity with the reports of Mwale *et al.* (2007) [6] reported that caused significant reductions in pod dry matter, Pod number, seed weight and harvest index (HI) leading to a decrease in final pod yield that was different between land races.

it is observed that pod yield was significantly higher in the control treatment (normal irrigation) while stressed treatments recorded lower pod yield. Among the stress treatments, maximum pod yield was found with the foliar spray of triacontanol (2.0 ml/l) followed by KCl (1%), methanol (2%), kaoline (6%) and nitrobenzene (20 ppm). These results are in conformity with the findings of Patil *et al*. (2009) [8] 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.

Among the stress mitigating treatments, foliar application of kaoline (6%) had higher cost of cultivation (59462.38 ₹/ha) and triacontanol (2 ml/l) had higher gross returns (113200 ₹/ha), net returns (67197.62 ₹/ha) and B:C ratio (2.46) followed by KCl (1%) and methanol (2%) respectively. This could be attributed to higher pod yield was obtained with higher input. Significantly lower net returns and B: C ratio was obtained in the stressed plot.

Table 1. Morpho-Physiological Parameters of groundnut as influenced by stress mitigating compounds.

Treatments	Plant height (cm)		Leaf area (dm^2 plant^{-1})		Total dry matter plant $^{-1}$ (g)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
T_1: Control*	15.4	16.2	7.4	7.5	25.07	26.80
T_2: Stress plot**	13.1	13.8	6.5	5.3	20.97	20.80
T_3= T_2+ Foliar application of KCl (1.0%).	15.1	15.5	7.1	6.2	22.33	25.94
T_4= T_2+ Foliar application of Triacontanol (2.0 ml/l)	15.3	16.1	7.4	7.3	23.40	26.00
T_5 = T_2+ Foliar application of Methanol (2%)	15.1	15.9	6.9	7.0	20.93	24.66
T_6 = T_2+ Foliar application of Kaoline (6%)	15.2	16.0	7.3	6.6	21.07	25.46
T_7 = T_2+ Foliar application of Methyl Jasmonates (0.5 ppm)	14.1	14.9	7.2	7.2	22.10	22.40
T_8 = T_2+ Foliar application of Urea (2% ppm)	14.8	15.6	7.1	6.9	20.40	25.46
T_9 = T_2+ Foliar application of Salicylic acid (500 ppm)	14.7	15.4	6.8	7.1	21.00	23.84
T_{10}= T_2+ Foliar application of Brassinosteroids (1 ppm)	15.0	15.9	7.2	6.6	20.63	24.40
S.Em.±	0.3	0.3	0.2	0.3	1.14	1.64
C.D. at 5%	0.8	0.9	0.5	0.9	3.33	4.76

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

Table 2. Yield and yield components of groundnut as influenced by stress mitigating compounds.

Treatments	No. of Pods plant^{-1}		Pod weight (g plant^{-1})		Pod yield (q ha^{-1})	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
T_1: Control*	19.4	21.2	8.9	13.4	29.6	31.8
T_2: Stress plot**	14.3	16.0	6.3	9.5	20.9	22.7
T_3= T_2+ Foliar application of KCl (1.0%).	18.6	19.1	8.1	12.2	26.8	28.9
T_4= T_2+ Foliar application of Triacontanol (2.0 ml/l)	19.3	20.2	8.5	12.8	28.3	30.4
T_5 = T_2+ Foliar application of Methanol (2%)	15.9	18.8	6.4	11.7	21.3	28.7
T_6 = T_2+ Foliar application of Kaoline (6%)	18.8	19.6	8.0	12.0	26.6	28.0
T_7 = T_2+ Foliar application of Methyl Jasmonates (0.5 ppm)	17.1	18.3	7.8	10.8	25.9	26.1
T_8 = T_2+ Foliar application of Urea (2% ppm)	15.3	17.6	6.5	10.4	21.6	23.70
T_9 = T_2+ Foliar application of Salicylic acid (500 ppm)	19.0	20.4	7.2	9.8	23.9	26.2
T_{10}= T_2+ Foliar application of Brassinosteroids (1 ppm)	18.7	17.8	6.9	9.6	22.8	24.9
S.Em.±	0.60	0.76	0.39	0.69	1.46	1.68
C.D. at 5%	1.80	2.21	1.13	2.10	4.44	4.91

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

Table 3: Cost of cultivation, Gross returns, Net returns and B:C ratio as influenced by stress mitigating treatments.

Treatments	Cost of cultivation (`₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1: Control*	53235.63	118400	65164.37	2.22
T_2: Stress plot**	45862.38	83600	37737.62	1.82
T_3: T_2+Foliar application of KCl (1.0%).	46236.00	107600	61364.00	2.33
T_4= T_2+ Foliar application of Triacontanol (2.0 ml/l)	46002.38	113200	67197.62	2.46
T_5 = T_2+ Foliar application of Methanol (2%)	49067.18	85200	36132.82	1.74
T_6 = T_2+ Foliar application of Kaoline (6%)	47365.00	106400	59035.00	2.25
T_7 = T_2+ Foliar application of Methyl Jasmonates (0.5 ppm)	59462.38	103600	44137.62	1.74
T_8 = T_2+ Foliar application of Urea (2% ppm)	49086.38	86400	37313.62	1.76
T_9 = T_2+ Foliar application of Salicylic acid (500 ppm)	49069.38	95600	46530.62	1.95
T_{10}= T_2+ Foliar application of Brassinosteroids (1 ppm)	49307.38	91600	42292.62	1.86
S.Em.±	-	2293.1	2293.1	0.04
C.D. at 5%	-	6725.6	6725.6	0.13

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

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