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EFFECT OF FOLIAR NUTRITION IN AMELIORATING DROUGHT TOLERANCE AND YIELD IN GROUNDNUT

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ABSTRACT

A field experiment was conducted at Dryland Farm of S.V. Agricultural College, Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Tirupati during *rabi* season, 2014-15. The study aimed to enhance drought tolerance and yield through foliar nutrition in groundnut crop under moisture stress conditions. IIn the present study, twelve treatments were imposed which include ten foliar nutrient sprays and one irrigated and one moisture stress control. The results revealed that, ssignificant variations for morphological, physiological and yield parameters were observed. Among the foliar spray treatments NPK- 19:19:19 @ 0.5%, KNO_3 @ 0.5% and KCl @ 1% at 60 DAS were recorded high chlorophyll content, high SPAD Chlorophyll Meter Reading (SCMR) values, moderate specific leaf area (SLA), moderate chlorophyll stability index (CSI), and low relative injury (RI) under moisture stress conditions. Foliar spray treatments NPK- 19:19:19 @ 0.5% recorded significantly highest pod yield (2335 kg ha^{-1}) followed by KNO_3 @ 0.5% (2190 kg ha^{-1}) and KCl @ 1% (2154 kg ha^{-1}).

KEYWORDS: Groundnut, Moisture stress, Nutrients, Foliar application

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the world's most chief protein rich vegetable oilseed legume crops. It is an important oil and protein source to a large portion of the population in Asia, Africa and the America. Major groundnut producing countries are China, India, Nigeria, USA, Indonesia, Argentina, Sudan, Senegal and Myanmar.

In India, groundnut occupies an area of 5.5 M ha producing 9.6 M t and with a productivity of 1750 kg ha^{-1} in India (National Research Center for Groundnut Annual report, 2014). Groundnut in Andhra Pradesh is cultivated in an area of 1.6 m ha during rainy season (*kharif*) and 0.3 m ha in post rainy season (*rabi*). Rayalaseema zone of Andhra Pradesh (Chittoor, Kurnool, Kadapa and Ananatapur) is a predominant groundnut growing region where more than 70 per cent area falls under rainfed condition. Hence, the productivity of groundnut in Andhra Pradesh is low (650 kg ha^{-1}).

Drought, a complex combination of stresses, involves both moisture stress and high temperature stress. Water is one of the major environmental factors influencing almost all aspects of plant growth and metabolism (Kramer, 1983). Different approaches were used to reduce the damage caused by drought such as selection of plants for higher water use efficiency, use of different growth regulators (GA_3, IAA and Cytokinines), seed treatment with osmoprotectants (Muna *et al*., 2013), foliar application of one per cent KCl (Aboelill, 2012.), exogenous application of organic compounds such as amino acids (Ardebili *et al*., 2012) etc.

Foliar feeding of fertilizers has been used as a means of supplying supplemental doses of minor and major nutrients, plant harmones, stimulants and other beneficial substances to plants. Observed effect of foliar fertilization have included yield increase, diseases and insect pest resistance, improved drought tolerance, and enhanced crop quality. Plant response is dependent on species, forms of fertilizer, concentration and frequency of application of nutrients (Anonymous, 1985).

Foliar-applied nutrients have indirect use for enhancement of stress resistance mechanism in field crops. Foliar application of key nutrients like Phosphorous (P), Potassium (K), Calcium (Ca), Zinc (Zn) and Boron (B) alleviates these deficiencies and increases drought tolerance by maintaining key physiological processes. Potassium (K) has the major role in osmo- regulation, photosynthesis, transpiration, stomatal opening and closing and synthesis of protein etc (Milford and Johnston, 2007). Hence, foliar fertilization can help in mitigating drought stress. Thus the objective of the present study

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was to know the physiological efficiency of foliar application of nutrients and enhancing yield and drought tolerance in groundnut under moisture stress conditions.

MATERIAL AND METHODS

A field experiment was conducted at S.V. Agricultural College Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University, during *rabi* season, 2014-15 which is geographically situated at 13.5°N latitude and 79.5°E longitude, with an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. Groundnut variety 'Dharani' was selected for the study whose duration was 110 days. The experiment was laid out in a Randomized block design with 12 treatments replicated thrice. The following treatments were foliar applied at 60 days after sowing (15 days after imposition of moisture stress). Treatments consists of T_1 - Control (Irrigated), T_2 - Control (Stress), T_3- Water spray, T_4- 2 % Urea, T_5- 2 % Di Ammonium Phosphate (DAP), T_6 - 1 % KCl, T_7 - 0.5 % $ZnSO_4$, T_8- 0.5 % $FeSO_4$, T_9 - 1 % Urea + 0.5 % Zn SO_4 + 0.5 % $FeSO_4$, T_{10}- NPK 19:19:19 @ 0.5 % (water soluble fertilizers), T_{11}- NPK 17:17:17 @ 0.5 % (water soluble fertilizers) and T_{12} - Potassium Nitrate @ 0.5 %.

The experiment was conducted in a sandy loam soil with a plot size of 3 x 3 m. The crop was sown on 18th December, 2014 with a spacing of 22.5 X 10 cm. Nitrogen was applied as basal dose @ 20 kg N ha^{-1} in the form of urea. Phosphorus and potash were given @ 40 kg P_2O_5 and 50 kg K_2O per ha basally. Gypsum was applied at 35 DAS @ 500 kg ha^{-1}. Hand weeding and hoeing was done twice at 20 days interval after sowing. Prophylactic measures were taken up to protect the crop from all insect pest and diseases throughout the crop growth period. Need based irrigations were given, however, the crop was irrigated to field capacity at 40 DAS and then there was no irrigation provided between 45-75 DAS. Treatments were foliar applied on 60th day after sowing *i.e.* 15 days after imposition of moisture stress.

Data was recorded on water use efficiency (WUE) traits, heat tolerance traits at 75 DAS (15 days after foliar nutrition) and yield parameters under moisture stress condition. Specific leaf area (SLA) was computed by following formula as SLA = A /WL (Where A = Leaf area; WL = Leaf dry weight at time t). The SCMR was measured for all four leaflets of third leaf from the top of the main axis using SPAD meter of Minolta company, NJ, USA (SPAD 502).

Relative injury per cent was measured using third leaf from top of respective plants.

Cell membrane integrity is tested by exposing leaves to high temperature and computing relative injury to the membranes in terms of electrolytes leakage. Relative injury per cent was measured using third leaf from top of the plant. The method used for measuring membrane damage was similar to the method given by Leopald *et al*. (1981).

$$\text{Per cent leakage (\%)} = \frac{\text{Ia}}{\text{Fa}} \text{x100}$$

where, Ia: Initial absorbance, Fa :Final absorbance.

Chlorophyll stability index CSI (%) was measured using third leaf from top of respective groundnut genotypes. Fresh leaf sample (0.1 g) was collected from the selected groundnut genotypes and placed in a 100 ml flask and heated it in a water bath for 60 min at 65°C. 10 ml of DMSO solution was added to treated and untreated samples. Respective checks samples are also maintained without imposing heat treatment. Both treated and untreated conical flasks were kept for overnight and the concentration of total chlorophyll is quantified by reading the optical density at 663nm and 645nm.

$$\text{Total Chl mg g}^{-1} = 20.02\ (\text{D645}) + 8.02\ (\text{D663})\ \text{X V}/1000\ \text{x W}.$$

The CSI of the leaf sample was calculated using the following formula

$$\text{CSI\%} = \frac{\text{Total chlorophyll of the heated sample}}{\text{Total chlorophyll of unheated sample}} \times 100$$

RWC is a reliable drought avoidance parameter adopted by plants. Leaflets were collected from the third leaf from the top of the primary branch of each genotype, and are floated in water for 6 hours and allowed to gain turgidity. Turgid weights are recorded and dried in hot air oven at 80°C to a constant weight to record dry weight. RWC is estimated and expressed in per cent using the following formula.

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

The data on seed yield and yield components were recorded at the time of harvest. The data were statistically analyzed as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The results of present investigation revealed existence of sufficient treatment variability among the treatments tested for WUE, thermotolerance and other traits *viz*., chlorophyll content and RWC. The data pertaining to plant height, WUE, thermotolerance and other traits at 75 DAS in response to foliar spray treatments were mostly discussed and presented here.

Plant height (cm)

Data presented in Table 1 revealed that foliar spray treatment NPK-19:19:19 @ 0.5% recorded 22 per cent higher plant height followed by KNO_3 @ 0.5 % and KCl @ 1% with 21 and 20 per cent higher plant height compared to control stress treatment. Plant height and number of leaves plant^{-1} were influenced by potassium spray and irrigation in both greengram varieties ML- 267 and LGG- 460. Maximum plant height was recorded by LGG- 460 with one per cent K_2SO_4 spray at vegetative stage followed by irrigation at 10 days after spray over complete drought (Rangamma and Naidu, 2006).

Specific leaf Area (SLA) (cm^2 g^{-1})

The Specific Leaf Area (SLA) is often considered as an indirect measure of leaf density. Significantly higher values of specific leaf area recorded in all treatments. Data presented in Table 1 revealed that, control irrigated treatment recorded significantly 20 per cent highest SLA compared to control stress treatment. The foliar spray treatment NPK- 19:19:19 @ 0.5% and KCl @ 1% showed significantly higher SLA by13 per cent followed by KNO_3 @ 0.5% spray (12 per cent) compared to control stress treatment. Higher SLA in these foliar spray treatments might be due to maintenance of higher chlorophyll content, leaf drymatter and higher photosynthetic rate due to the supply of the nutrients at critical stages (Pradeep and Elamathi, 2007; Zayed *et al.,* 2011).

SPAD chlorophyll meter readings (SCMR)

SPAD meter quantifies the greenness or relative chlorophyll content of leaves. The SPAD Chlorophyll Meter Reading (SCMR) is an indication of leaf nitrogen status, since SLN (Specific leaf nitrogen) determines the differences in WUE, it can be visualized that SCMR could reflect well in WUE differences. Significant differences for SCMR were found among foliar spray treatments (Table 1). Control irrigated treatment showed 6 per cent higher SCMR compared to control stress treatment. Among the foliar spray treatments significant difference were recorded. NPK- 19:19:19 @ 0.5% showed 5 per cent high SCMR value followed by KCl @ 1% and KNO_3 @ 0.5% (4 per cent) compared to control stress treatment. The overall mean SCMR of rainfed condition (57.6) was significantly higher than overall mean in irrigated condition (47.4). This might be due to relatively less restricted leaf expansion and with relatively less chlorophyll formation under irrigated conditions (Kashiwagi *et al*., 2006).

Relative membrane injury (RI) (%)

Relative membrane injury values were high in control stress treatments compared to control irrigated conditions. Data presented in Table 1 revealed that, control irrigated treatment recorded 50 per cent low relative injury compared to control stress treatment. Among the foliar spray treatments, NPK- 19:19:19 @ 0.5% and KNO_3 @ 0.5% showed significantly 30 and 29 per cent low RI compared to control stress treatment followed by KCl @ 1% with 26 per cent low RI. Relative injury increased with increase in temperature from 50 ^{o}C to 55 ^{o}C. This is because at lower temperature the RI was too low to cause substantial electrolyte leakage in a reasonable time (Talwar *et al*., 2002).

Chlorophyll stability index (CSI) (%)

The chlorophyll stability index is an indication of the stress tolerance capacity of plants. This leads to increased photosynthetic rate, more dry matter production and higher productivity. Hence, a high CSI value means that the temperature stress did not have much effect on chlorophyll content of plants. Data presented in Table 1 revealed that, Among the foliar spray treatments to mitigate moisture stress, the foliar spray treatment KNO_3 @ 0.5% recorded significantly 26 per cent highest CSI, followed by NPK- 19:19:19 @ 0.5% and KCl @ 1 % with 25 per cent high CSI compared to control stress treatment. Chlorophyll stability index and ash content showed significant and positive correlation with pod yield under moisture stress conditions. This might be due to decrease in internal water content of protoplasm and loss of chlorophyll a:b ratio which might be the result of premature senescence of leaves (Reddy *et al*., 2003).

Table 1. Effect of foliar application of nutrients on plant height (cm), physiological traits and yield of groundnut (var. Dharani) under moisture stress conditions.

S.No.	Treatments	At 75 DAS						At harvest
		Plant height (cm)	SCMR	SLA ($cm^2\ g^{-1}$)	RI (%)	CSI (%)	RWC (%)	Pod Yield ($kg\ ha^{-1}$)
1.	Control (Irrigated)	22.89	45.8	169.0	12.6	80.1	94.1	3149
2.	Control (Stress)	16.82	43.2	141.3	22.1	55.2	60.8	1668
3.	Water spray	18.67	44.4	146.5	19.9	60.2	65.6	1815
4.	2% Urea	18.21	44.0	151.2	18.8	63.1	66.2	1700
5.	2% DAP	19.12	44.6	149.9	18.7	64.2	65.1	1844
6.	1% KCl	21.07	44.9	160.1	16.3	68.9	71.1	2154
7.	0.2% $ZnSO_4$	20.92	44.0	150.7	17.7	66.2	66.0	1903
8.	0.5% $FeSO_4$	19.34	44.2	147.8	18.2	63.1	67.2	1815
9.	1% Urea + 0.2% $ZnSO_4$ + 0.5% $FeSO_4$	20.67	44.3	148.0	18.3	63.8	65.7	1885
10.	N:P:K- 19:19:19 @0.5%	21.62	45.3	159.2	15.7	69.1	71.3	2335
11.	N:P:K- 17:17:17 @ 0.5%	20.13	44.2	150.1	16.9	66.6	68.6	2048
12.	0.5% KNO_3	21.36	45.0	158.3	15.7	69.5	71.3	2190
	Mean	20.07	44.49	152.7	17.6	65.8	77.96	2042
	CD (P=0.05)	3.16	0.861	5.37	0.93	2.06	2.08	285
	SEm ±	1.08	0.301	1.83	0.32	0.70	0.71	97

Relative water content (RWC) (%)

The values of RWC are often considered as the appropriate measure of plant water status and considered to be the sensitive index of plant water content especially when plants are exposed to cellular water deficit conditions. Data presented in Table 1 revealed that, the foliar spray treatments NPK- 19:19:19 @ 0.5% and KNO_3 @ 0.5% recorded 15 per cent high RWC value followed by KCl @ 1% (14 per cent) compared to control stress treatment due to in groundnut, application of potassium improves relative water content of plants under normal as well as water stress conditions. The maintenance of plant water economy by potassium application in terms of high relative water content could be ascribed to the supposed role of potassium in stomatal resistance, water use efficiency and lowered transpiration rate (Umar and Moinuddin, 2002). This suggests that potassium has a positive role in turgidity maintenance and continual cell growth (Ardestani and Rad, 2012).

Pod yield (kg ha^{-1})

Present data in Table 1showed that, pod yield varied significantly among the treatments studied under moisture stress situation. Among the foliar spray treatments control irrigated treatment recorded 48 per cent higher pod yield compared to control stress treatment. Among foliar spray treatments, NPK- 19:19:19 @ 0.5% showed 38.5 per cent highest pod yield followed by KNO_3 @ 0.5% (36 per cent) and KCl @ 1 % (31 per cent) compared to control stress treatment. Increase in groundnut yield may be cultivated under drought conditions along with potassium fertilization in order to minimize the adverse effects of water stress (Umar, 2006) and the increased yield may be due to the role of nitrogen fertilizer in increasing photosynthetic rate, synthesis of metabolites and translocation of assimilates to the seed as zinc is the activator of several enzymes in the plants (El Habbasha and Taha, 2008).

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