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Sodium Nitroprusside Modulated Drought Stress and Improved Productivity and Quality of Peanuts (*Arachis hypogea* L.) under Skipped Irrigations

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ABSTRACT

Background: Drought stress (DS) has emerged as one of the prime abiotic stresses adversely affecting the quality and productivity of peanuts worldwide, necessitating finding adequate and farmer-friendly mitigation strategies.

Methods: Therefore, a multi-year field trial was carried out to optimize the exogenously applied sodium nitroprusside for boosting the yield and quality of peanuts under different irrigation regimes. The trial was comprised of five DS levels imposed through skipped irrigations at vegetative, flowering, pod and grain formation stages, whereas there were three sodium nitroprusside (SNP) doses (100, 200 and 300 µM) along with water spray as a control treatment.

Result: DS severely affected peanut yield and oil quality while foliar application of SNP improved peanut yield, yield-related traits and oil quality. The DS at the vegetative stage imparted the least adverse effects by producing higher peanut yield, hundred seed weight and pods per plant while, DS at flowering and pod formation stages seriously reduced hundred-grain weight, pod yield and seed yield of peanuts. Foliar application of 200 µM SNP improved chlorophyll, relative water content, membrane stability index, 100-seed weight, pod yield and oil quality compared with other treatments. Contrastingly, the 300 µM SNP dose remained superior by recording significantly higher oil and protein contents. Based on these findings, foliar feeding of 200 and 300 µM SNPmight be recommended to peanut growers for boosting yield and quality (oil and protein content) of peanut respectively and it might be developed as a potent strategy to attain sustainable peanut yield under DS conditions.

Key words: Foliar feeding, Groundnuts, Oil seed legumes, Sodium nitroprusside, Water scarcity.

INTRODUCTION

Recently, drought stress (DS) has become a major environ-mental stress causing yield reduction of field crops including peanut (*Arachis hypogea* L.) worldwide (Iqbal *et al.,* 2023; Ahmad *et al.,* 2021). The DS tends to disrupt crop plant's anatomical, physiological and metabolic processes, leading to cell membrane instability, photosynthetic suppression and abnormal stomatal conductance (Abbas *et al.,* 2023; Yasir *et al.,* 2023). Likewise, the DS in peanuts reduced seed weight by adversely affecting photosynthesis which led to a significant decline in the partition of assimilates (Iqbal, 2018) and loss of moisture from pods which reduced grain weight, yield and quality (Changxing *et al.,* 2017). Moreover, DS caused low soil and leaf water potential, disturbing the physio-biochemical processes and upset the biosynthesis of chlorophyll, relative water content, photosynthetic activity and osmotic adjustment in crop plants (Banka *et al.,* 2024). Furthermore, it disrupted the turgor potential in leaves, altered the stomatal regulation and reduced photosynthesis and transpiration rates (Abeed *et al.,* 2020). Previously, it was inferred that moisture stress at critical crop vegetative growth stages (Pod formation and grain filling) caused pronounced yield reduction and grain quality (protein and oil contents) also deteriorated.

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Under DS, different osmoprotectants tend to mitigate the deleterious effects of water scarcity in crop plants. Nitric oxide (NO) is generally applied as a ferrous sulfate or sodium nitroprusside (SNP) increased chlorophyll contents and antioxidant enzymes under DS which improved seedling growth (Yasir *et al.,* 2021). Additionally, it also improved the photosynthetic activity, root-shoot growth, relative water contents, photosynthetic processes and stomatal conductance leading to better grain and biomass production. Likewise, the SNP being an antioxidant, reduced oxidative damage through detoxifying biosynthesis of reactive oxygen species (ROS) including lipid peroxidation under DS (Zhang *et al.,* 2007). Moreover, it played a crucial role in regulating the stomatal closure and improved the nitrate reductase activity. Furthermore, it triggered the biosynthesis of different biochemical compounds like phenolics, flavonoids, ascorbic acid, soluble sugars and proline along with abscisic acid (ABA) which assisted crop plants to survive the moderate periods of DS (Gelaye and Luo, 2024).

Despite the increasing economic pertinence of peanuts as an oil seed crop and raw material of different food industries, its yield and grain quality have been seriously reduced by DS (Latha *et al.,* 2024), which necessitates conducting fresh studies to find biologically *via*ble mitigation options (He *et al.,* 2024). Research gaps exist concerning optimized doses of foliar application of SNP for mitigating the deleterious impacts of drought stress in peanuts. Thus, the research hypothesis of this study entailed that peanuts could respond differently to different concentrations of exogenously applied SNP at different growth stages of peanuts under drought stress imposed through skipped irrigation at different vegetative and reproductive growth stages. Therefore, the present study was carried out to investigate the impact of foliar feeding of SNP in different concentrations on the productivity and quality of peanuts under DS imposed through skipped irrigation regimes.

MATERIALS AND METHODS

Experimental site description

A field trial was carried out at the University Research Farm Hafiz Abad, College of Agriculture BZU-Bahadur Sub-Campus Layyah, Pakistan (30° 58′ 49″ N, 70° 57′ 55″ E) to evaluate the effect of foliage applied SNP on productivity and quality of peanut under different irrigation regimes. The soil of the experimental area was sandy loam. Pre-sowing experimental soil analysis revealed that it had pH 8.1, electrical conductivity 2.00 ds m^{-1}, organic matter 0.48%, nitrogen concentration 0.22 g kg^{-1}, available phosphorus 8.1 ppm and extractable potassium 83 ppm. Weather data for the crop-growing seasons have been presented in Fig 1.

Experimental details

This multi-year field study consisted of five irrigation levels *viz.* control with no irrigation: Drought stress at vegetative stage DSV, drought stress at flowering stage DSF, drought stress pod formation stage DSPF, drought stress grain formation stage DSGF, along with four SNP levels *viz.* T_1 = control, T_2 = 100 µM SNP, T_3 = 200 µM SNP, T_4 = 300 µM SNP. The experiment was laid out in a randomized complete block design with a split plot arrangement and replicated thrice. Irrigation levels were allocated to the main plots, while foliar application of SNP was assigned to the sub-plots. The net plot size was 6 m × 3 m.

Crop husbandry

Primary seedbed was prepared using 2-cultivation with tractor mounted cultivator and field was irrigated up to 12 cm as pre-sowing irrigation. After 4 days of pre-sowing

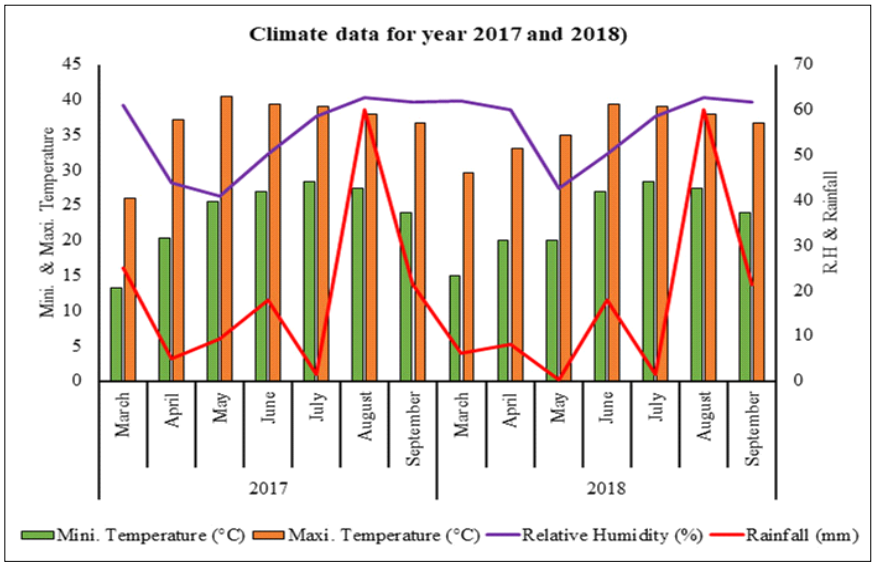


Fig 1: Climatic data for crop growth seasons of 2017 and 2018 at Layyah, south of Punjab province, Pakistan.

irrigation, the final seedbed was prepared using tractor tractor-mounted cultivator with 2-ploughing followed by planking. The peanut variety BARI-2011 was collected from BARI-Chakwal and was sown on 23rd March 2017 and 27th March 2018 using a seed rate of 100 kg nuts ha^{-1}. Nuts were dribbled using a seed dibbler by maintaining a P×P distance of 15 cm and R×R distance of 45 cm. One-meter border was used to separate irrigation treatments to avoid the effect of irrigation treatments over controlled treatments. All NPK fertilizer was applied at 20, 80 and 60 kg ha^{-1} in the form of Urea, DAP and SOP respectively. While P, K and half Nwere applied at sowing while remaining N was applied with second irrigation. The crop was irrigated asper experimental treatments. Weeds were controlled by manual hoeing which was done 30 days and 50 days after crop sowing. The crop was attacked by termites which were controlled by flooding chlorpyrifos (2.5 L ha^{-1}). The crop was harvested when 90% of the pods has attained physiological maturity.

SPAD-Chlorophyll and relative water contents

For determination of chlorophyll contents SPAD-502 chlorophyll meter was used. The chlorophyll contents from five plants were measured and an average was obtained. To determine relative water content (RWC), fresh leaves were taken from plants and immediately shifted to the laboratory to get fresh weight. Then these leaves were soaked in distilled water and kept at room temperature for 24 hours under the dark. After 24 hours, soaked leaves were taken out from the water, dried with tissue paper and weighed to get a turgid weight. Then these leaves were oven-dried at 75°C till a constant dry weight was acheived. The RWC was calculated using the following formula:

$$RWC\ (\%) = \frac{FW - DW}{TW - DW} \times 100$$

Yield and yield-related traits

Five plants were uprooted manually using a spade, sundried, pods were separated from the plants and pod yield was measured using electric balance. Pods were separated from five randomly selected plants and the number of pods were counted and averaged to determine the number of pods per plant. Pods were de-hulled manually, 100 nuts were manually counted and weighed using electrical balance to get 100-seed weight. For kernel yield determination, pods were shelled and kernel yield was determined with the help of electric balance. For estimating the biological yield (kg ha^{-1}), plants were harvested from each plot and sundried. After drying the weight of plants was recorded and converted into kg per hectare. The shelling percentage was measured with the help of the formula:

$$Shelling\ (\%) = \frac{Weight\ of\ kernels}{Weight\ of\ pods} \times 100$$

For each treatment harvest index (%) was determined with the help of a formula suggetsed by Iqbal (2018).

$$H.I\ (\%) = \frac{Grain\ yield}{Biological\ yield} \times 100$$

Quality parameters

Groundnut samples were dehydrated under sunlight; pods were separated and shelled to obtain nuts. The nuts were oven-dried, then grinded to prepare a sample. The oven-dried samples were kept in polyethylene bags for successive analysis of nutrients. The Micro-Kjeldahl method was used to determine total nitrogen concentration. The protein content (GPC) (%) was measured by multiplying total nitrogen content with a conversion factor of 5.823. Seed oil was also extracted by solvent extraction with a Soxhlet apparatus (Soxhlet, 1879). Seed oil contents were calculated using the Soxhlet technique according to AOAC, (1990).

Statistical analyses

The recorded data from the experimental units were subjected to Barlett's test for estimating the significance of the year effect using Statistix 10 software (Analytical Software, USA). Additionally, the analysis of variance (ANOVA) technique (two-way) was used to estimatethe overall significance of the employed treatments. Thereafter, treatment means were compared using the least significant difference test (LSD) at a 5% probability level for the estimation of significance among treatments.

RESULTS AND DISCUSSION

Drought stress significantly reduced SPAD-chlorophyll value. Data showed that maximum SPAD-chlorophyll (47.17) was observed where drought applied at the vegetative stage while minimum SPAD-chlorophyll value was observed under DS conditions (Table 1). Regarding the foliar application of SNP maximum SPAD-chlorophyll value was observed where 200 µM SNP was applied. However, the minimum value was recorded with water spray (control). The interaction effect of SNP doses and drought growth stage was found to be non-significant in both years of study (Table 1).

Likewise, the maximum relative water content (RWC) value was found where drought applied at the vegetative stage which was at par with all other drought treatments except control where no irrigation was applied. However, a minimum RWC value was observed with control (Table 1). Regarding the foliar application of SNP, the maximum RWC was recorded when 200 µm was sprayed while; the minimum RWC was found with water spray. The interaction effect was observed non-significant in both years of study (Table 1). The membrane stability index (MSI) is an important indicator of drought stress. Higher MSI was noted in plots where drought was applied at the vegetative stage and was at par with other drought treatments except control (Table 1). However, considerably lesser MSI was observed

where no irrigation was applied. Regarding SNP application, maximum MSI value was observed in all SNP treatments except with water spray while, the interaction effect was found to be non-significant in both years of study (Table 1). The number of pods per plant (NPP) was found more where drought was applied at the vegetative and flowering stages while NPP was minimal where drought was applied at grain formation and pod formation stages and controlled treatment where no irrigation was applied throughout the season (Table 1). Foliar application of SNP had a significant effect in improving NPP under drought stress and maximum NPP was recorded in treatment where 200 µM of SNP was applied while minimum NPP was recorded in treatment with water spray. The interaction effect remained non-significant for both years of study (Table 1).

Drought stress significantly reduced hundred seed weight (HSW) and minimum HSW was recorded in plots where groundnut was grown as rainfed while, maximum HSW was recorded where drought was imposed at the vegetative stage (Table 2). Foliar application of SNP has improved the adverse effect of drought and maximum HSW was recorded with foliar application of 200 µM SNP which was at par with all other SNP treatments while minimum HSW was recorded in treatments where water was sprayed (Table 2). Their interaction was recorded to be non-significant for both years of the study. Maximum pod yield (PY) was observed when DS was applied at the vegetative stage while minimum PY was observed in plots where no irrigation was applied (Table 2). Foliar application of SNP improved PY and maximum PY was obtained from plots treated with 200 µM SNP while, minimum PY was observed with water spray during 2nd year of study.

The DS and exogenous application of SNP had a significant effect on kernel yield (KY) and biological yield (BY) during both years of investigation. Data showed that maximum KY and BY were recorded when drought was imposed at vegetative stages in groundnut which was at par with all treatments of drought imposition at various growth stages. However, minimum KY and BY were recorded in controlled treatment where groundnut was grown under rainfed conditions (Table 2). Foliar application of SNP improved both KY and BY in all drought-treated plots. However, foliar application of 200 µM SNP significantly produced higher KY and BY which was at par with other levels of SNP compared with controlled treatments which produced minimum KY and BY in both years of study. The interaction effect for these traits was found to be non-significant during both years (Table 2).

The DS and foliar application of SNP had a significant effect on shelling percentage (SP) and harvest index (HI) during both years of experimentation. More SP and HI were found in plots where drought was applied at the vegetative stage while less SP and HI were found in control plots where no irrigation was applied to groundnut. Foliar application of SNP significantly improved both SP and HI and maximum SP and HI were recorded with foliar application of 200 µM SNP while, minimum SP and HI were recorded with water spray during both years. Statistically non-significant interaction was recorded for SP and HI during both years (Table 3).

The results depicted that DS imposed at different growth stages of peanut and varying doses of SNP had statistically significant impact on yield contributing traits and kernel yield, whereas their interaction showed a non-significant effect for oil contents (OC) and protein contents (PC) (Table 3). The results also indicated that the highest and most significant OC were recorded in plots where DS was imposed at the grain formation stage followed by DS

Table 1: Effect of foliar application of sodium nitroprusside on SPAD-Chlorophyll, relative water contents (RWC), membrane stability index (MSI) and number of pods per plant (NPP) of peanut under DS at different growth stages.

Drought	SPAD-Chlorophyll		RWC (%)		MSI (%)		NPP	
environment	2017	2018	2017	2018	2017	2018	2017	2018
DS	37.916D	36.432D	54.540B	54.624B	34.760B	33.926B	30.917C	32.750C
DSV	47.178A	45.695A	66.057A	66.557A	42.588A	42.421A	37.500A	40.083A
DSF	41.927C	40.136C	65.913A	65.497A	42.559A	42.918A	36.667A	38.667AB
DSPF	43.192C	41.575BC	64.802A	64.886A	43.021A	42.553A	33.333B	34.833BC
DSGF	44.541B	43.049B	64.442A	63.442A	44.028A	43.503A	34.500B	35.250ABC
LSD (≤0.05)	1.3447	1.7107	2.9439	7.1272	3.35	1.6505	2.0382	5.05
				Foliar application of SNPs				
Control	41.621C	40.018B	57.977C	58.043C	38.670B	38.350B	32.800C	34.400C
100 µm	43.283AB	41.619AB	64.107B	63.974B	41.707A	41.326A	34.667B	36.600B
200 µm	44.615A	43.102A	66.909A	66.776A	43.038A	42.844A	36.667A	38.400A
300 µm	42.284BC	40.771B	63.610B	63.211B	42.150A	41.736A	34.200B	35.867B
LSD (≤0.05)	1.5473	1.6139	1.7033	1.6778	2.8583	2.5744	0.9765	1.2409
D × SNPs	NS	NS	NS	NS	NS	NS	NS	NS

Means sharing different letters differ significantly at 5% P value. Here, DS = Drought stress; DSV = Drought stress at vegetative stage; DSF = Drought stress at flowering; DSPF = Drought stress at pod formation; DSGF = Drought stress at grain formation; SNP = Sodium nitroprusside.

employed at the grain formation stage. However, the highest PC were recorded in plots where DS was imposed at the vegetative stage. Contrastingly, the minimum OC and PC were recorded in plots where crops were grown under drought conditions. Foliar application of SNP improved the quality of groundnut; however, foliar application of 300 µm SNP produced more OC and PC compared with other SNP levels while less OC and PC were recorded with water was sprayed during years of investigation (Table 3).

Groundnut is an important oil seed crop grown throughout the world in tropical and subtropical regions for human consumption due to its high nutritive value with 25% protein and 50% oil contents (Banka *et al.,* 2024). The DS at various growth stages adversely affects peanut yield by interrupting different morphological, physiological, biochemical and anatomical processes. Likewise, DS at various growth stages in peanuts significantly affected SPAD-chlorophyll value, relative water contents and MSI in the current investigation and peanuts grown with no irrigation significantly reduced all these traits however, foliar application of SNP significantly improved relative water contents, SPAD-chlorophyll value and MSI. The DS reduces

Table 2: Effect of foliar application of sodium nitroprusside on hundred seed weight (HSW), pod yield (PY), kernel yield (KY) and biological yield (BY) of peanut under DS at different growth stages.

Drought	HSW (g)		PY (kg ha^{-1})		KY (kg ha^{-1})		BY (kg ha^{-1})	
environment	2017	2018	2017	2018	2017	2018	2017	2018
DS	48.95D	48.96C	1767.1D	1845.1D	933.1D	981.4D	3267.1D	3392.9D
DSV	61.92A	62.21A	2326.6A	2404.1A	1492.6A	1539.2A	3826.6A	3961.6A
DSF	57.23B	57.73AB	2130.0AB	2206.0AB	1296.0AB	1351.8AB	3630.0AB	3765.0AB
DSPF	55.32BC	56.32AB	2052.6BC	2123.3BC	1218.6BC	1280.2BC	3552.6BC	3685.1BC
DSGF	52.85C	52.85BC	1915.5CD	1987.3CD	1081.5CD	1143.2CD	3415.5CD	3548.8CD
LSD (≤ 0.05)	2.49	6.72	203.05	202.16	203.05	200.18	203.05	209.98
				Foliar application of SNPs				
Control	54.13B	54.47B	1919.2B	1993.9B	1085.2B	1139.5B	3419.2B	3550.9B
100 µm	55.04AB	55.45AB	2025.5AB	2100.1AB	1191.5AB	1246.5AB	3525.5AB	3657.8AB
200 µm	55.13AB	57.05A	2164.5A	2239.1A	1330.5A	1384.8A	3664.5A	3796.8A
300 µm	56.71A	55.45AB	2044.3AB	2119.4AB	1210.3AB	1265.9AB	3544.3AB	3677.3AB
LSD (≤0.05)	1.74	1.99	139.66	139.90	139.66	140.49	139.66	139.58
D × SNPs	NS	NS	NS	NS	NS	NS	NS	NS

Means sharing different letters differ significantly at 5% P value. Here, DS = Drought stress; DSV = Drought stress at the vegetative stage; DSF = Drought stress at flowering; DSPF = Drought stress at pod formation; DSGF = Drought stress at grain formation; SNP = Sodium nitroprusside.

Table 3: Effect of foliar application of sodium nitroprusside on shelling percentage (SP), harvest index (HI), oil content (OC) and protein content (PC) of peanut under DS at different growth stages.

Drought	SP (%)		HI (%)		OC (%)		PC (%)	
environment	2017	2018	2017	2018	2017	2018	2017	2018
DS	52.58C	53.00C	28.46D	28.83C	41.98E	42.94B	22.38D	23.38D
DSV	63.91A	63.79A	38.85A	38.71A	42.09D	43.22A	24.88A	26.03A
DSF	60.62AB	61.07AB	35.58AB	35.79AB	42.15C	43.25A	24.14B	25.27B
DSPF	59.09B	60.04AB	34.15BC	34.60B	42.33B	43.15A	24.07C	24.78C
DSGF	56.22BC	57.31B	31.54CD	32.10BC	42.38A	43.17A	24.03C	24.80C
LSD (≤0.05)	4.60	4.28	3.99	3.69	0.02	0.17	0.04	0.12
				Foliar application of SNPs				
Control	56.09B	56.75B	31.51B	31.88B	41.60D	42.53D	23.74D	24.83B
100 µm	58.41AB	58.98AB	33.57AB	33.87AB	42.08C	43.09C	23.88C	24.84B
200 µm	60.93A	61.35A	36.00A	36.19A	42.38B	43.32B	23.94B	24.91AB
300 µm	58.51AB	59.10AB	33.78AB	34.08AB	42.68A	43.63A	24.04A	24.96A
LSD (≤0.05)	2.84	2.74	2.60	2.52	0.02	0.14	0.04	0.10
D × SNPs	NS	NS	NS	NS	0.07	0.45	0.12	0.34

Means sharing different letters differ significantly at 5% P value. Here, DS = Drought stress; DSV = Drought stress at vegetative stage; DSF = Drought stress at flowering; DSPF = Drought stress at pod formation; DSGF = Drought stress at grain formation; SNP = Sodium nitroprusside.

turgor pressure in phloem vessels, thereby increasing the sucrose viscosity to limit its flow through the conducting cells toward the sinks (Yasir *et al.,* 2023). Regarding the foliar application of SNP, a maximum SPAD-chlorophyll value was observed where 200µM SNP was applied. The increase in chlorophyll contents by foliar application might be due to the ROS inhibition or maintain the photosynthetic mechanism stability (Tian *et al.,* 2015). The SNP plays a significant role in protecting membrane damage, sequestering Na+ ions in the vacuole and improving cell wall repair and all these are related to improving antioxidant defense systems (Pokhrel and Dubey, 2013). Foliar application of SNP also improves plant tolerance to osmotic stress in many plants. SNP increases the chlorophyll content in plant leaves, hence playing an important role in the greening of seedlings (Zhang *et al.,* 2007). It also regulates stomatal opening and closing through ABA signaling (Laxalt *et al.,* 2016). Membrane stability is an important drought indicator and is adversely affected by DS and in the current study, MSI was significantly reduced which might be due to increased variation in protein contents of the cell membrane, which had increased the permeability of the cell membrane (Pooja *et al.,* 2020). However, foliar application of SNP improved the MSI under DS which might be due to lesser leakage of electrolytes (Ahmad *et al.,* 2022). The DS caused a significant reduction in RWC in the current study which is in line with the previous study conducted by Wasaya *et al.* (2021). Foliar application of SNP improved RWC in peanut crops and a significantly 16% higher RWC was recorded with 200 µM application of SNP compared with control in the current investigation which might be because of more proline content which coincides with improvements in RWC under DS and maintained water balance in plants (dos Santos *et al.,* 2022).

Hundred seed weight was increased when 200 µM SNP was applied while less HSW was recorded with control in this study. More HSW was observed when DS was applied at the vegetative stage while less HSW was found when drought was applied at the reproductive stages. The reduced HSW at pod and grain development stages might be owing to stress-induced reduced ability of kernel to serve as a sink which led to a serious decline in seed weight (Ahmad *et al.,* 2024). Likewise, the incidence of DS at the seed-filling stage promoted senescence and reduced the duration of seed-filling along with disrupting the source-sink relationship (Hossain *et al.,* 2024). Application of 200 µM SNP increased kernel yield compared with other treatments. Similar to our findings, it has been reported that DSboosted the endogenous ABA levels which adversely affected the potential of reproductive parts to acquire the assimilates. Additionally, DS-induced increment in the biosynthesis and accumulation of non-reducing sugars resulted in ovary abortion, suboptimal grain weight set and reduced grain yield (Ahmad *et al.,* 2022). Moreover, DS has been reported to be associated with a reduction in water potential which suppressed acid invertase activity in seeds and sucrose import to the seed was inhibited (Farooq *et al.,* 2017). Particularly, DS suppressed the vegetative growth of cereals through a reduction in leaf water content (El Sabagh *et al.,* 2019), which disrupted the stomatal conductance and the rate of the photosynthesis process declined. Another disadvantage associated with reduced stomatal was elevation in leaf temperatures, which ultimately triggered the leaf wilting (Farooq *et al.,* 2017). Contrarily, SNP being a prime signaling molecule exhibited the potential for improving the growth and physiological function of plants under water-limited conditions, by elevating water potential under osmotic stress, which could be a possible reason for increasing grain and biomass yield (Iqbal *et al.,* 2025). The NO plays a pivotal role in plant developmental processes, including seed germination, plant development, photosynthesis, stomatal movement and recovery of cell membrane and increases chlorophyll synthesis and declines chlorophyll degradation of plants which ultimately improves grain yield under stress conditions (Ahmad *et al.,* 2024).

Similar to our findings, it was inferred that water-limited conditions restricted the accumulation of seed constituents (protein and starch) by inhibiting the biosynthesis of enzymes and proteins along with reducing seed weight and seed yield (Ochatt *et al.,* 2015). Akin to our findings concerning the seed quality traits, it was reported that seed protein quality was largely a genotypic trait, however, DS caused degradation and decline of seed protein content. To cope with DSconditions, SNP application remained effective in promoting the morphological traits of crop plants along with supporting the vital physiological processes which led to improved seed protein content. Moreover, our findings were in concurrence with previously reported results whereby SNP application enhanced the enzymatic activity under DS that increased the oil contents (Farooq *et al.,* 2017).

CONCLUSION

Based on the recorded findings of this study, it may be inferred that DS imparted significantly drastic impacts on the relative water content, SPAD-chlorophyll value, peanut yield and quality, while foliar-applied SNP remained effective in inducing drought tolerance in peanuts. Under DS, significantly higher peanut yield was obtained with foliar application of 200 µM SNP which was associated with more SPAD-chlorophyll value, relative water contents, 100-seed weight and pod yield. Similarly, peanut quality was also improved by foliar application of SNP, however higher protein and oil content were obtained with foliar application of 300 µM SNP. Higher peanut yield under foliar application of sodium nitroprusside was also associated with more membrane stability under DS conditions which ultimately improved peanut yield and quality. We recommend that future research must focus on assessing higher doses of sodium nitroprusside alone and in combination with other drought-ameliorating compounds like citrus acid for boosting the yield and quality of peanuts.

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Disclaimers

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Informed consent

No animals or humans were subjected to experimental treatments in this trial.

Conflict of interest

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