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Response of groundnut (*Arachis hypogaea* L.) varieties to seed endophytic treatment for drought tolerance

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Abstract
A field experiment to investigate the "Response of seed endophytic bacterial inoculation on various genotypes of groundnut (*Arachis hypogaea* L.) under deficit irrigation conditions" was conducted at the Regional Agricultural Research Station (RARS), Palem during the rabi season of 2022–2023. Experiment was comprised of 15 treatment combinations consisting of 3 main treatments and 5 sub treatments laid in a split plot design with three replications. Main treatment containing 3 varieties *viz.*, V_1:K-6, V_2: TAG-24 and V_3: Visishta and sub treatment included 5 irrigation schedules *i.e.,* I_1: irrigation at 10 days, I_2: irrigation at 10 days interval with Seed treatment with consortium of endophytic bacteria, V_3: irrigation at 15 days interval, V_4: irrigation at 15 days interval with Seed treatment with consortium of endophytic bacteria and V_5: IW: CPE ratio at 0.8. The investigation's findings revealed that the variety Visishta had a noticeably greater pod yield ((2805 kg ha^{-1}) over other varieties, kernel yield (1729 kg ha^{-1}) and haulm yield (5348 kg ha^{-1}) over TAG-24 and was on par with K-6. Among irrigation schedules, irrigation at 10 days interval with seed treatment with consortium of endophytic bacteria was recorded significantly higher pod yield (2785 kg ha^{-1}) and haulm yield (5323 kg ha^{-1}) over irrigation at 15 days interval but was on par with rest of the treatments.

Keywords: Field experiment, seed endophytic bacterial inoculation, groundnut (*Arachis hypogaea* L.)

Introduction
Groundnut (*Arachis hypogea* L.) is commonly recognized as the king of vegetable oilseed crops and it belongs to Leguminosae family. This crop is grown within the latitudinal range of 40ºN to 40ºS of the equator. It is also considered as king of vegetable oil seed crops in India which can be grown during rainy, winter and summer seasons. It occupies a predominant position in Indian oilseed economy. Groundnut comprises of 44–56% edible oil; globally, is the fourth largest source of edible oil. In terms of acreage, groundnut occupies first position in India with an area of 6.09 million hectares and 101 lakh tonnes of production with productivity of 1863 kg ha^{-1} (agricoop.nic.in, 2021-22). Groundnut has specific moisture needs due to its peculiar feature of producing pods underground. The rabi crop produces substantial yield as compared to the kharif crop and requires irrigations due to scanty rainfall during winter. There is a gap in productivity of groundnut at our state level and national level due to the fact that the potentiality of the crop is not fully exploited by the Indian farmers due to many factors, of which proper irrigation and suitable variety for a particular season need consideration. Given the limits of intensive agriculture (pollution, degradation of biodiversity, or soil desertification), it is necessary to develop sustainable alternatives to respond to future agricultural demand. Among these sustainable alternatives is the use of microbial bio-stimulants. Inoculation of plants with beneficial micro-organisms promotes plant growth and increases drought tolerance in arid or semiarid areas (Marulanda *et al*., 2006) [5]. Identifying a suitable irrigation schedule with endophytic seed treatment and suitable variety may achieve a breakthrough in productivity. Thus, efficient alternative to adopt drought tolerant varieties with different irrigation schedules to overcome shortage of water by increasing the productivity of groundnut crop under assured irrigation during rabi season is essential. The current investigation was conducted in three groundnut varieties—K-6, TAG-24, and Visishta with irrigation schedules for analysing yield and yield attributes.

Materials and Methods

During the agricultural season of Rabi 2023-24, the field experiment took place in the A - 3 block at the Regional Agricultural Research Station (RARS), Palem. The station is located at 16°31'04" N latitude and 78°14'52" E longitude, situated at an altitude of 642 meters above mean sea level within the Southern Telangana Zone. The texture of the soil was sandy loamy. Throughout the crop growth period (09-11-2023 to 18-03-2024), the mean weekly maximum and minimum temperatures fluctuated between 28.5°C to 37.0°C and 16.1°C to 25.7°C, respectively. RH-I ranged from 63% to 91%, while RH-II varied between 35% and 60.

Experiment was comprised of 15 treatment combinations consisting of 3 main treatments and 5 sub treatments laid in a split plot design with three replications. Main treatment containing 3 varieties *viz.*, V_1: K-6, V_2: TAG-24 and V_3: Visishta and sub treatment includes 5 irrigation schedules *i.e.*, I_1: irrigation at 10 days, I_2: irrigation at 10 days interval with Seed treatment with consortium of endophytic bacteria, V_3: irrigation at 15 days interval, V_4: irrigation at 15 days interval with Seed treatment with consortium of endophytic bacteria and V_5: IW: CPE ratio at 0.8. The data was recorded on Dry matter production, Number of pods plant^{-1}, Test weight (100 kernel weight in grams), Shelling percentage, Pod yield (kg ha^{-1}), Kernel yield (kg ha^{-1}), Haulm yield (kg ha^{-1}) and Harvest index (HI,%). The statistical analysis was carried out by using "Analysis of variance techniques". The significance was assessed by 'F' value at 5% level of significance. The value of critical difference (C.D.) for examining treatment means for their significance was done at 5% level.

Results and Discussion

Dry matter production

Data recorded on dry matter production of groundnut varieties under different irrigation schedules was represented in Table1. Over view of data indicated that DMP of groundnut was significantly influenced by varieties and different irrigation schedules, though interaction effect of groundnut varieties under different irrigation was not significant over entire growth stages. Significantly higher DMP of pod, haulm and total was observed in Visishta (7233 kg ha^{-1}) than K-6 (6723 kg ha^{-1}) and TAG-24 (6489 kg ha^{-1}). This is because of different groundnut genotypes have different growth patterns, which could be caused by variations in their genetic make-up. Behera *et al.* (2015) [1] reported similar results. Irrigation at 10 days interval with seed treatment (7137 kg ha^{-1}) was recorded significantly higher DMP over other treatments but was on par with irrigation at 10 days interval (6943 kg ha^{-1}) and lower DMP was recorded with irrigation at15 days interval (6406 kg ha^{-1}). According to Sandhya *et al.* (2010) [9], planting bacterial isolates *P. entomophila, P. stutzeri, P. putida, P. syringae*, and *P. monteilli* had a greater positive impact on plant dry biomass during drought stress than non-stressed conditions.

Number of pods plant^{-1}

Among groundnut varieties, significantly greater number of pods plant^{-1} was observed in Visishta (36.5) over TAG-24 (32.9) and with K-6 (34.7). This could be because the variety's better genotypic traits account for its larger number of pods per plant (Table 1). Similar findings were reported by Bhagavatha Priya (2014) [2]. In irrigation schedules, irrigation at 10 days interval with seed treatment (36.1) produced a significantly greater number of pods plant^{-1} over irrigation at 15 days interval (32.4) and was on par with irrigation at 10 days interval (35.1) and IW:CPE ratio at 0.8 (34.9) and irrigation at 15 days interval with seed treatment (35.0). Pods per plant^{-1} were significantly fewer when there is lack of moisture to meet evapotranspiration demands during peg penetration and pod development which may be the cause of the soil's moisture potential. Frequent irrigations are favourable for crop growth, leading to higher number of pods plant^{-1}. (Chaudhary *et al*., 2015) [3]. The interaction effect of varieties and irrigation schedules was not significant.

Test weight (100 kernel weight in grams)

Data pertaining to test weight of groundnut was significantly differed among groundnut varieties but among different irrigation schedules and their interaction between groundnut varieties and irrigation schedules was not significant. Under various groundnut varieties, the highest 100-kernel weight was recorded in Visishita (38.3 g) which was

Table 1: Dry matter production and Yield attributes of groundnut varieties as influenced by different irrigation schedules.

Treatments	Dry matter production (kg ha^{-1})	Number of pods plant^{-1}	Test weight (g)	Shelling percentage
Mainplot (varieties)				
V_1: K-6	6723	34.7	35.7	64.3
V_2: TAG-24	6489	32.9	32.5	61.7
V_3: VISISHTA	7233	36.5	38.3	65.9
SEm±	120.3	0.4	0.3	0.3
C.D(P=0.05)	472	1.5	1.2	1.3
Subplot (Irrigation schedules)				
I_1: Irrigation at 10 days interval	6943	35.1	35.9	64.7
I_2: I1+ Seed treatment with consortium of endophytic bacteria	7137	36.1	36.5	64.7
I_3: Irrigation at 15 days interval	6406	32.4	34.7	62.6
I_4: I3+ Seed treatment with consortium of endophytic bacteria	6775	35.0	35.2	63.4
I_5: IW: CPE ratio 0.8	6813	34.9	35.3	64.3
SEm±	110.7	0.6	0.4	0.6
C.D(P=0.05)	323	1.7	NS	NS
Interaction				
Effect of irrigation schedules with same varieties				
SEm±	269.0	0.9	0.7	0.8
C.D(P=0.05)	NS	NS	NS	NS
Effect of irrigation schedules with different varieties				
SEm±	209.4	4.7	0.7	1.0
C.D(P=0.05)	NS	NS	NS	NS

significantly superior over other varieties *viz.*, K-6 (35.7 g) and TAG-24 (32.5 g) (Table 1). This could be the result of hereditary varietal characteristics, such as kernel shape and size. (Deva *et al*., 2022) [4]. Among irrigation schedules it was determined to be non-significant, although irrigation at 10 days with seed treatment (36.5 g) was recorded higher 100-kernal weight compared to irrigation at 10 days interval (35.9 g), IW:CPE ratio at 0.8 (35.3), irrigation at 15 days interval with seed treatment (35.2) and lower test weight was observed in irrigation at 15 days interval (34.7).

Shelling percentage

Data pertaining to shelling percentage of groundnut was neither among irrigation schedules and nor their interaction was found to be a non-significant. Among different groundnut varieties it was significantly differed with each other. In the group of different varieties, Visishta (65.9) was yielded maximum shelling percentage which significantly superior over K-6 (64.3) and TAG-24 (61.7) (Table 1). Genetic variation of the genotypes was identified as the cause of the variations in peanut cultivars' 100 kernel weight (g). (Mouri *et al.*, 2018) [7]. Maximum shelling percentage was observed with irrigation at 10 days interval with seed treatment (64.7) than irrigation at 10 days interval (64.7), IW:CPE ratio at 0.8(34.3), irrigation at 15 days interval with seed treatment (63.4) and irrigation at 15 days interval (62.5) was recorded lower shelling percentage without any significant variation.

Pod yield (kg ha^{-1})

A thorough examination of the data showed that groundnut varieties and irrigation schedules both significantly affected pod yield, but their interaction between the two being determined to be non-significant. Data on groundnut varieties showed that Visishta (2805 kg ha^{-1}) has yielded significantly higher pod yield over TAG-24 (2523 kg ha^{-1}) and K-6 (2573 kg ha^{-1}). This could be because different kinds of varieties have different genetic potentials for higher test weights and other traits that contribute to yield. Higher pod plant^{-1} (Table 2) and number of kernel plant^{-1} which contribute to the higher pod yield in Visishta. Similar findings were reported by Mamatha *et al.*, (2022) [6]. Naik *et al.*, (2018) [8] reported that these higher yield characteristics could result from higher growth parameters like biomass output and branch count. The microbial community has a rapidly expanding market that offers plant growth enhancement and increased yield under biotic and abiotic challenges, with an approximate yearly growth rate of 10% (Timmusk *et al.*, 2017) [13]. In different irrigation schedules, significantly higher pod yield was observed with irrigation at 10 days interval with seed treatment (2785 kg ha^{-1}) which was on par with irrigation at 10 days interval (2742 kg ha^{-1}),

Table 2: Yield and Harvest index of groundnut varieties as influenced by different irrigation schedules.

Treatments	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Mainplot (varieties)				
V_1: K-6	2573	1656	5128	33.4
V_2: TAG-24	2523	1521	4893	33.7
V_3: VISISHTA	2805	1729	5348	34.1
SEm±	55.2	31.9	84.9	0.6
C.D(P=0.05)	217	125	333	NS
Subplot (Irrigation schedules)				
I_1: Irrigation at 10 days interval	2742	1688	5130	34.8
I_2: I1+ Seed treatment with consortium of endophytic bacteria	2785	1741	5323	34.5
I_3: Irrigation at 15 days interval	2394	1508	4938	33.3
I_4: I3+ Seed treatment with consortium of endophytic bacteria	2591	1618	5106	33.0
I_5: IW: CPE ratio 0.8	2656	1620	5119	33.0
SEm±	80.4	52.6	80.7	0.8
C.D(P=0.05)	235	154	236	NS
Interaction				
Effect of irrigation schedules with same varieties				
SEm±	123.4	71.2	189.9	1.5
C.D(P=0.05)	NS	NS	NS	NS
Effect of irrigation schedules with different varieties				
SEm±	136.2	87.5	151.1	1.5
C.D(P=0.05)	NS	NS	NS	NS

followed by IW:CPE ratio at 0.8 (2656 kg ha^{-1}), irrigation at 15 days interval with seed treatment (2591 kg ha^{-1}) and lower pod yield was recorded with irrigation at 15 days interval (2394.0 kg ha^{-1}). This could be the result of maintaining regular intervals of appropriate soil moisture during the crop growth period, as well as increased nutrient availability that led to improved nutrient uptake and a greater number of pods (Table 1) in I_1.

Kernel yield

With respect to data pertaining to kernel yield of groundnut, maximum kernel yield was recorded in Visishta (1729 kg ha^{-1}) which was on par with K-6 (1656 kg ha^{-1}) and TAG-24 (1521 kg ha^{-1}) (Table 2) has produced significantly lesser kernel yield due to their lesser number of pods palnt^{-1}, shelling percentage, pod yield and number of kernel plant^{-1}. Saravannan *et al.*, (2018) reported that these may be due to cumulative performance of kernel genotypes. In different irrigation schedules, significantly higher kernel yield was produced with irrigation at 10 days interval with seed treatment (1741kg ha^{-1}) over irrigation at 15 days interval (1508 kg ha^{-1}) and was on par with irrigation at10 days interval (1688 kg ha^{-1}), IW:CPE ratio at 0.8 (1620.0 kg ha^{-1}) and irrigation at 15 days interval with seed treatment (1618 kg ha^{-1}). Increased irrigation frequency was primarily responsible for the improved kernel production because it

kept the soil moisture content in the active root zone at a suitable level for the duration of the crop period. (Vaghasia *et al*., 2017) [15]. The interaction effect between varieties and irrigation schedules was not significant.

Haulm yield (kg ha^{-1})

Scrutiny of the data on groundnut varieties revealed that maximum haulm yield was recorded in Visishta (5348 kg ha^{-1}) which is significant over TAG-24 (4893 kg ha^{-1}) and was on par with K-6 (5128 kg ha^{-1}) (Table 2). The variations in the morphological characteristics of their vegetative growth were reflected in the haulm yield. This may be primarily caused by the genetic potential of the different types and the plants' intake of nutrients. The outcomes confirm the conclusions of Udaya Bhargavi (2022) [14]. Higher haulm yield was recorded with irrigation at 10 days interval with seed treatment (5323 kg ha^{-1}) which was on par with irrigation at 10 days interval (5130 kg ha^{-1}) followed by IW:CPE ratio at 0.8 (5119 kg ha^{-1}), irrigation at 15 days interval with seed treatment (5106 kg ha^{-1}) and lower haulm yield was recorded with irrigation at 15 days interval (4938 kg ha^{-1}). The haulm production of groundnuts was eventually decreased by reductions in plant height, branches per plant, dry matter accumulation, and canopy development due to moisture stress. Sounda *et al.* (2006) [12] also reported results that were similar. The interaction effect between varieties and irrigation schedules are not significant.

Harvest index (HI,%)

Analysis of the data on harvest index was represented in Table 2. The harvest index could not be significantly impacted by groundnut varieties and irrigation schedule. Correspondingly, their interaction was non-significant between varieties and irrigation schedules. Data on varieties exhibited that, Visishta (34.1%) was recorded significantly higher than K-6 (33.4%) and TAG-24 (33.7%) was yielded lesser harvest index. Among different irrigation schedules, irrigation at 10 days interval (34.8%) was recorded maximum harvest index followed by irrigation at 10 days interval with seed treatment (34.5%), irrigation at 15 days interval (33.3%), irrigation at 15 days interval with seed treatment (33.0%) and IW:CPE ratio at 0.8 (33.0%). Similar findings were described by Soni *et al*., 2019 [11].

Conclusion

The result from the investigation revealed that variety Visishta was recorded as significantly higher yield and yield attributes *i.e.*, test wight, shelling percentage, kernel yield, haulm yield and harvest index and was on par with K-6. Among irrigation schedules irrigation, maximum yield was observed in irrigation at 10 days interval with seed treatment with consortium of endophytic bacteria which was on par with irrigation at 10 days interval and irrigation at 15 days interval with seed treatment.

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