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To Examine the Nature of Drought Tolerance in Sugarcane Crops using Diazotrophic Bacteria

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ABSTRACT: A sort of relationship between roots and fungus, mycorrhizae is present in over 80% of plant species. Most mycorrhizal fungi belong to the AM genus, therefore it's safe to assume that few species are immune. Interactions between plants and fungi improve several aspects of crop production, including water absorption, disease resistance, crop yield, and nutrient availability. Through biological nitrogen fixation, *Gluconacetobacter diazotrophicus* seems to have a significant impact on the plant's nitrogen supply. Not only is *G. diazotrophicus* able to cure red rot disease, but it is also famous for solubilizing phosphate and making indole acetic acid (IAA), a natural hormone for plants. Sugarcane plants were found to benefit from inoculation with AM fungi and *G. diazotrophicus* in a number of ways. These included nitrogen fixation in the plant's stems, roots, and leaves; growth hormone production; and protection from stress and pathogens as well as solubilization and mobilization of soluble nutrients.

Keywords: Sugarcane, Diazotrophic Bacteria, Fungi, inoculation.

INTRODUCTION

Among the Poaceae family, sugarcane stands out commercially. This species is a member of the Saccharum family and has its origins in Southeast Asia and South Asia. There are currently Saccharum officinarum, spontaneum, robustum, sinense, barberi, and edule are the six species that make up the genus Saccharum (Singh *et al.,* 2020). The majority of these changes occurred in the twenty-ninth century as a result of several taxonomy revisions. Modern sugarcane cultivars are the product of hybridization between different species; most are 90% *S. offcinarum* and 10% *S. spontaneum*. This type of squash is classified as Saccharum spp. In 2017, the Americas accounted for 55.7% of global sugarcane production, while Asia accounted for 37.2%. With 758 Mt, or 41% of the global total, produced in 2017, Brazil surpassed all other countries as the top sugarcane producer. With respective contributions of 306, 104, 103, 73, and 57 metric tons (Mt) of sugarcane, Thailand, India, China, and Mexico all play a substantial role in the global supply. This culture's economic relevance is affected by its various functions. Sugar and cane molasses, two byproducts of sugarcane processing, are widely used in Brazil as both food and animal feed, in addition to being a key ingredient in ethanol. The versatile nature of sugarcane means that production will likely keep going up. There are a lot of different genera and species of diazotrophic plant growth-promoting bacteria that may be found in sugarcane (Taulé *et al*., 2016). Some examples are Burkholderia, Azotobacter, and Azospirillum. Another species is Gluconacetobacter diazotrophicus, which is basically Acetobacter diazotrophicus. Research in this field has been intensified by Brazilian scientists following the finding that G. diazotrophicus other cultures benefit from sugarcane-associated diazotrophic bacteria. PAL5T, HCC10, HRC54, CBAmC, Azospirillum amazonense, Paraburkholderia tropica, and Herbaspirillum rubrisubalbicans. To test the effects on sugarcane plant growth, PPe4T were introduced into the plant's root system (dos Santos *et al*., 2019).

It is impossible to exaggerate sugarcane's economic and industrial significance. Whether it's hot and dry at sea level or chilly and rainy at higher altitudes, this plant can be found in tropical and subtropical regions. Sugar isn't the only valuable thing that comes out of sugarcane. Other things like ethanol, bagasse, press mud, and molasses are also produced, along with chemicals, plastics, paints, and synthetics, which are essential resources for many other industries.

The host plant can benefit from PGPR-plant interactions in a number of ways, including colonizing bacteria, plant growth-promoting chemicals produced by rhizobacteria, antifungal and antibacterial substances, and biocontrol agents (James *et al.,* 1997). All of the aforementioned procedures were found to be cooperating in other cases.

LITERATURE REVIEW

The adsorption of phosphate (P) to soil colloids makes it an essential nutrient for high sugarcane yields all through the crop's life cycle. "Some plant growth-promoting bacteria (PGPBs) have the potential to increase plant phosphorus availability and produce phytohormones that boost crop development, quality", and yield (Rosa *et al.,* 2022). Consequently, this study set out to investigate how PGPB inoculation and phosphate fertilisation affected the yield, technical quality, "nitrogen (N) and phosphorus (P) contents of sugarcane leaves. The experiment took place in Ilha Solteira in São Paulo, Brazil. Eight inoculations of three species of PGPBs (*Azospirillum brasiliense*, Bacillus subtilis, and Pseudomonas fluorescence) and five phosphorus rates (0, 25, 50, 75, and 100 percent of the recommended P_2O_5 rate) were utilized in this investigation, which included three replications of the randomized block design. Following inoculation with B. subtilis and P." fluorescens, sugarcane showed an increase in leaf P content. Results from sugarcane stalk inoculation and P_2O_5 rates are correlated. Fertilizers that are either too much or too little phosphate are bad for sugarcane crops, regardless of whether growth-promoting microorganisms are used. We suggest a combination of *A. brasilense* and *B. subtilis* inoculation with 45 kg ha^{-1} of P_2O_5 for increased stalk yield. As a result of its increased sugar output and 75% reduction in the allowed P_2O_5 rate, this treatment is a better and more sustainable option for sugarcane crop development.

Sugarcane Genotypes' Growth and Yield. Sugarcane accounts for over 75% of all sugar produced across the globe. It is an economically viable biofuel and biomass crop that contributes significantly to the manufacture of bioethanol and the generation of electricity (World Sugar Statistics, 2014). When compared to the breeding histories of other key broad-acre crops, sugarcane's breeding history is rather short. Sugarcane breeding activities all around the world are focused on improving disease resistance, cane output, and sugar content in order to achieve these aims (Oliveira *et al*., 2003).

Cultivated in various tropical and subtropical climates across the world, it is a significant economic crop. with the majority of it being farmed in the United States (FAO, 2014). The genetic engineering (GE) interaction is a substantial source of diversity in sugarcane yield in many breeding programmes, and it has the potential to have a large impact on breeding programme selection in the future (Bartz, 2014). It seems that gene-location (GL) links are more important for cane yield than gene-year (GY) or gene locus/year (GLY) relationships in some studies. However, it should be noted that this is not the case in all of them. Increasing our understanding of the environmental and genetic factors that influence GE interaction might aid in the creation of more targeted selection approaches, however little research and major results have been made in this area thus far. Sugarcane genetic interactions were not found to be impacted by soil type or weather conditions in a recent assessment of soil and meteorological characteristics effecting sugarcane development. The study was conducted across and inside China and Australia and found no evidence of genetic interactions.

Sugarcane Producing Regions in India. Researchers from the AICRP-Sugarcane network have had a significant impact on sugarcane yield and output in Brazil. "After Brazil, India is the world's second-largest producer of sugarcane (15.81%) and sugar in addition to its dominance as the world's greatest" producer and consumer of sugar (15.93 percent), China is also the world's seventh largest exporter of the sweetener (2.80 percent) (2015- 16 - Aprilto January) (Leite *et al.*, 2014). Productivity has risen from 48.0 tons/hectare (1970-71) to roughly 70 tonnes per hectare (1990-91). (2015-16). In contrast, cane output has increased from 126 million tonnes in the year 1970-71 to 341 million tonnes in the current year (2015-16).

METHODS

"On the Root Colonization of *G. Fasciculatum*and the Growth of Sugarcane", *G. Diazotrophicus* Has an Impact. Filling cement pots with sterilised sand and soil (1:1) was done. A thin, homogeneous coating of 50 g pot-1 *G. fasciculatum* soil-based root inoculums was buried two centimetres below the soil's surface. At two setts pot-1, sugarcane setts of the var (CoC 24) were planted. "The setts were treated with a culture suspension of *G. diazotrophicus* containing 1 107 CFU ml-1" prior to planting. With no *G. diazotrophicus* or *G. fasciculatum*, a total control was maintained.

When *G. diazotrophicus* is employed as an inoculant against "*G. fasciculatum*, the incidence of red rot disease" decreases. "*G. fasciculatum* root-based soil inoculums at 50 g pot-1 were applied two centimetres below the soil surface as a thin film" of homogeneous thickness in cement pots of 20 kilogramme capacity. CoC 24 vartwo .'s budded sugarcane sets (pot-one) were planted and maintained.

Qualitative and quantitative investigation of sugarcane root exudates anionic fraction

"*G. diazotrophicus* and AM fungi impact sugarcane growth and yield"

Experiment on sugarcane yield and development with *G. diazotrophicus* and AM fungus injected with varying concentrations of inorganic N and P fertilisers in the field.

Objective of the Study

1. To examine Diazotrophic Bacteria Sugarcane Crops for Drought Tolerance Nature.

RESULT AND DISCUSSION

Exclusion and Control of Am Fungi In Sugarcane Farms. This experiment demonstrated that there are considerable variations in root colonization percentage and spore amount 100g-1 soil. Twenty locations in the Atarahi District were used to collect and categorize soil samples from sugarcane rhizospheres. The results showed that eight of the samples were clay loam. The organic carbon content ranged from 0.36 to 0.77 percent in each sample, while the bioavailable phosphorus concentration was 11.18 to 21.10 kg/ha.

Table 1: Sugarcane rhizosphere soil samples were collected and AM fungus isolated.

1.	Atkadpur	Clay loam	8.0	0.46	0.70	13.24	50.0	100.5
2.	Baghmurtza	Sandyclay	8.5	0.53	0.76	19.38	32.0	65.0
3.	Bans Gopalpur	Sandy clay	7.4	0.32	0.47	19.10	39.2	80.5
4.	Barrre Patti	Sandy loam	7.3	0.40	0.36	21.10	35.0	86.0
5.	Bhakura	Sandy clay	8.44	0.50	0.71	12.00	29.8	67.0
6.	Baboopur	Sandy clay	8.67	0.48	0.69	16.00	30.0	80.0
7.	Alamgirpur	Clay loam	8.94	0.48	0.72	14.00	40.5	84.0
8.	Chak Pahalawan Tahir	Clay loam	8.64	0.48	0.62	18.00	40.0	80.0
9.	Chaka Banki	Sandy clay	8.05	0.50	0.65	11.00	41.3	80.0
10.	Chaktali	Sandy clay	8.86	0.50	0.61	13.00	34.9	67.0
11.	Baijapur	Sandy clay	8.27	0.50	0.49	12.00	34.5	67.0

While the inherent physico-chemical properties of the soil had no effect on AM fungal colonization or spore population, the phosphorus level of the soil had a detrimental effect on spore production. Soil AM spore populations were from 65.0 to 126.0 percent and root colonization percentages for sugarcane roots ranged from 32.0 to 66.0 percent. Babarakha yielded the highest root colonization % (66.0) and spore number $100g^{-1}$ (126.0). Samples collected from Baghmurtza had the lowest rates of root colonization (32.0) and spore count $100g^{-1}$ soil (65.0). Gerdemann and Trappe (1974) used a stereozoom microscope on the isolated spores of *G. sporulatum* and found several species of fungus (Table 2).

Table 2: Different AM fungus isolates from sugarcane rhizosphere soil samples were discovered and described.

Sr. No.	Characters	Glomus mosseae	Glomus fasciculatum	Glomus versiforme	Acaulospora Laevis	Gigaspora margarita
1.	Size of spore	120	100-120µm	125-150 µm	400 µm	200-300 µm
2.	Spore shape	Globose	Globose hypogeous	Globose	Globose	Ectocarpic
3.	Colour of spore	Yellow to brown	Yellow to reddish brown	Yellow to brown	Outer wall - brown Inner wall- Hyaline Ellipsoid	White when young and slightly yellowish at maturity
4.	Sporocarp	Present	Present	Present	Present	Absent
5.	Thickness of spore wall	3-4 µm	4-14 µm	3-4 µm	4-8 µm	> 20µm
6.	Subtending hyphae	Cylindric flared	Absent	Cylindric or flared	Not observable	Bulbous 30-50 µm

Table 3: Different AM fungus isolates from sugarcane rhizosphere soil samples were discovered and described.

Sr. No.	Soil texture	Total AM fungal spore population per 100 g of soil in cach soil types	Glomus mosseae	Glomus fasciculata	Glomus vermiform	Acaulospora laevis	Gigaspora margarita
1.	Sandy Clay	82.0	16.0	38.0	5	9	14
2.	Sandy loam	80	16.0	34	6	10	14
3.	Clay loam	102.0	22.0	48.0	7	11	14
4.	clay	78.0	16.0	38.0	5	9	10

Table 4: Sugarcane var. CoC 24 was used to test several AM fungus species under pot culture conditions.

Sr. No.	Am fungal inoculation	Percent root colonization			Spore number 100g of rhizosphere soil			Acid phosphates activity (µg/24 hrs. 10g¹ of root)			Alkaline phosphates activity (µg/24 hrs-1 10g¹ of root)		
		Sampling period in days			Sampling period in days			Sampling period in days			Sampling period in days		
1.	Glomus mosseae	42.00	54.90	61.20	144.60	164.90	175.00	26.090	27.60	28.90	24.30	26	25.90
2.	Glomus fascicula tum	53.60	61.30	78.20	151.90	168.30	180.	27.30	28.60	28	25	27.90	26.30
3.	Glomus versifor me	26.30	39.60	46.20	128.30	156	165.60	23.60	25.90	26.60	21.90	21.30	21.00
4.	Acaulos pora laevis	38.60	49.30	57	139	163.90	170	25.30	26.30	28.90	23	24	23.30
5.	Gagaspora margarit	30.30	42	52.60	130.90	156.30	164.30	24	26	28.60	21.30	22.60	21.60
	SE	2.59	2.12	2.02	2.27	0.52	1.14	0.31	0.17	0.33	0.45	0.47	0.61
	CD (p=0.05)	7.24	6.03	5.75	6.49	1.50	3.28	0.89	0.51	1.95	1.30	1.35	1.76

Control of sugarcane red rot using *G. diazotrophicus* and *G. fasciculatum*. There was an increase in the incidence of red rot disease in both the individual inoculations of *G. diazotrophicus* and the combination inoculations of *G. fasciculatum*, as reported in (Table 5). *G. diazotrophicus* and "*G. fasciculatum* inoculation greatly decreased the incidence of red rot disease". Comparatively, in comparison to the individual inoculations of *G. diazotrophicus* and fungus AM.

Patients who received both *G. diazotrophicus* and *G. fasciculatum* on 180 DAP had the greatest decrease in illness incidence "(67.00%), followed by those who received *G. diazotrophicus* alone (42.22) and *G. fasciculatum* only (25.67)."

Table 5: "Control of red rot disease in sugarcane" by *G. diazotrophicus* and *G. fasciculatum* inoculation alone and in combination.

Sr. No.	Treatments	Occurrence of disease incidence %		Percent reduced on over control	
		Sampling period in days		Sampling period in days	
		120	180	120	180
1.	Uninoculated control	0.00	0.00	0.00	0.00
2.	Celletotrichum falcatum alone	67	43.02	0	0
3.	Celletotrichum falcatum + G diazotrophicus	38	26.84	43.45	42.22
4.	Celletotrichum falcatum + G fasciculatum	44.62	34.25	35.62	25.67
5.	Celletotrichum falcatum + G fasciculatum + G diazotrophicus	20	14.00	68.00	67.00
	SE	1.7411	1.3066		
	CD (p- 0.05)	4.96	3.73		

CONCLUSIONS

More than 80% of plant species have mycorrhizae, a type of interaction between roots and fungus. The AM fungi are the most prevalent kind of mycorrhizal fungus, and there probably aren't that many species that aren't affected. Fungal relationships have numerous positive effects on crop plants, such as enhancing nutrient availability, water uptake, disease resistance, and crop output. The nitrogen supply to the plant appears to be greatly influenced by Gluconacetobacter diazotrophicus through biological nitrogen fixation. In addition to its capacity to treat red rot disease, G. diazotrophicus is well-known for solubilizing phosphate and producing indole acetic acid (IAA), a plant growth hormone. Researchers discovered that inoculating sugarcane plants with *G. diazotrophicus* and AM fungi enhanced their growth and development in several ways, including nitrogen fixation in the plant's roots, stems, and leaves, the production of growth hormones, and the solubilization, mobilization, and protection of sugarcane plants from stress and pathogens.

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