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Effect of Different Levels of Phosphorus on germination percentage, dry matter production and sheath moisture at different stages of Sugarcane as Influenced by Cane Trash and Mycorrhizae

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ABSTRACT

The field experiment was conducted at RARS, Anakapalle on the effect of different levels of phosphorus on germination percentage, dry matter and sheath moisture at different stages of sugarcane in two plant crops and ratoon crop in presence and absence of cane trash and mycorrhizae. The experiment was laid out in split plot design with four main levels and four sub levels. The main levels consists of control (M_1), mycorrhizae alone (M_2), cane trash and mycorrhizae (M_3) and cane trash alone (M_4). The four sub levels consists of 0, 50,100 and 150 kg P_2O_5 ha^{-1}. Higher germination percent was observed with the application of cane trash in combination with mycorrhizae (M_3) over cane trash alone (M_4) and control (M_1), but was on par with (M_2) i.e application of mycorrhizae alone. The lowest germination percent was recorded with control respectively in both the plant crops. Ratoon crop also showed significantly higher germination percent with cane trash plus mycorrhizae. The mean drymatter produced across the cane trash and mycorrhizal treatment was significantly higher at inorganic P level of 50 kg P_2O_5 ha^{-1} . The interaction effect in presence or absence of cane trash and mycorrhizae on inorganic P was not found significant at all the three stages. Higher sheath moisture per centage was recorded in the treatment receiving 50 kg P_2O_5 ha^{-1} in plant and ratoon crops. Significantly higher sheath moisture content was recorded when inorganic P @ 50 kg P_2O_5 ha^{-1} was applied in presence of both cane trash and mycorrhizae in plant and ratoon crop. The interaction between inorganic P levels with cane trash and mycorrhizae was found significant.

1. INTRODUCTION

Sugarcane is one of the important cash crops in India and plays pivotal role in both agricultural and industrial economy of the country. India the largest producer of sugar cultivating sugarcane in an area of 5.04 million hectares with a production of 338.168 million tonnes and productivity of 70 tonnes per hectare (2010-2011). Sugarcane is an exhaustive crop and depletes soil nutrients heavily. India ranks second in the world contributing to 22 % of world's production. Andhra Pradesh ranks fifth in sugarcane crop area of the country with a share of 4.83 per cent (0.22 M.ha) with an average production of 20.30 Mt contributing to 5.83 per cent of the total production of the country. In India approximately 6.5 million tonnes of sugar cane trash are being produced every year and most of the residues are usually burnt in the field due to lack of proper composing techniques. Phosphorous is one of the essential elements required in optimum amounts for the growth and development of the plants. About 98% soils have inadequate supply of available Phosphorous (Hansan, 1996) and likely to induce deficiency of this mineral. Application of 100 kg P_2O_5 ha^{-1} through SSP or DAP along with 112 kg nitrogen ha^{-1} was found optimum for sugarcane in sandy loam soils (Devi *et al.,* 2007). The plants which are deficient in P, show retarded growth and causes dark green colouration due to enhancement of anthocyanin formation (Khan *et al*., 2009). Phosphorous is the important nutrient for plant growth and root development in crops (Eftkhari *et al*., 2010). Application of phosphorus increases the dry matter yield, intermodal length and quality parameters in sugarcane (Tilib *et al*., 2004). Earlier, sugarcane crop was not responding to P application in A.P. With the advent of physiologically active improved sugarcane variety P nutrition to sugarcane crop played a vital role in yield, and quality improvement. The symbiotic associations formed by fungi with roots, known as mycorrhizae, are of particular importance in the uptake of phosphorus and some micronutrients thus enhancing the beneficial microbial populations in the root zone. These endomycorrhizae form external hyphal networks in the soil and grow extensively within the cells of cortex. Vesicular- arbuscular mycorrhizal (AM) fungi colonize plant roots and ramify into the surrounding bulk soil extending the root depletion zone around the root system. They transport water and mineral nutrients from the soil to the plant while the fungus is benefiting from the carbon compounds provided by the host plant. In low input agricultural systems, cultural practices such as organic amendments. are known to enhance Arbuscular mycorrhizae formulation and fungal propagules (Darzi *et al*., 2009). These changes in crop growth and yield produced by various organic amendments are ascribed to changes in the physical, chemical or biological properties of the soils. The response of crop growth and yield to different organic amendments may be related to changes in population of AM fungi, as in conventional high input farming system.

2. MATERIALS AND METHODS

The experiment was laid out in split plot design with four main treatments and four sub levels with a early maturing variety 93 A 145. The setts were selected from the short crop. The seed rate per hectare was 16,000 ha^{-1}. The main treatments consists of control (M1), mycorrhizae alone (M2), cane trash and mycorrhizae (M3) and cane trash alone (M4). The sub levels consists of 4 levels of phosphorus i.e., 0,50,100 and 150 kg P_2O_5 ha^{-1}. The fertilizers for the plant crop are 112 kg N, 75 kg P_2O_5 and 100 kg K_2O ha^{-1} and

224 kg N, 75 kg P_2O_5 and 100 kg K_2O ha^{-1} for ratoon crop. The phosphorus in the form of single super phosphate and potassium fertlisers in the form of muriate of potash were applied as per the treatments. The nitrogen was applied at 45 and 90 days after planting for plant crop and at stubble shaving and 45 days after planting for ratoon crop. The cane trash (pre decomposed) was applied @3t ha^{-1} three days after planting. The mycorrhizae was applied @12.5 kg ha^{-1} 24 hours after application of chemical fertilizers. The EM1 culture was applied on the trash @ 1kg ton $^{-1}$ after application of chemical fertilizers. Weeding and irrigation was done as and when required. Harvesting was done when the cane attains maturity.

The number of germinated buds in each treatment from the net plot of plant crop was recorded at 35 days after planting and expressed as percentage of the total number of buds originally planted. Plants of one meter row length from the destructive sampling area were cut to the base, chopped into small pieces, air dried and then oven dried at 70^0C till constant weight was attained and oven dry weight of each sample was determined and total dry matter production was computed. Five primary stalks were sampled at random from the sample rows in each treatment of both plant and ratoon crops at 120, 180 and 240 days after planting/ ratooning and harvest. The 3-6 leaf sheaths were separated from the cane stalks and used for determination of moisture. After taking fresh weight, the sheaths were dried in oven at 70^0 C for 48 hours and dry weights were recorded and percent moisture was computed on green weight basis

3. RESULTS AND DISCUSSIONS

The germination percentage was influenced by application of cane trash and mycorrhizae which varied from 74.9 to 94.1 in 1^{st} plant crop and 77.3 to 91.8 in 2^{nd} plant crop. During both the years of study, significantly higher germination percent (94.1and 91.8) was observed with the application of cane trash in combination with mycorrhizae (M_3) over cane trash alone (M_4) and control (M_1), but was on par with (M_2) i.e application of mycorrhizae alone. Significantly lowest germination percent was recorded with control (74.9 and 77.3) in both the plant crops. Pooled data of 1^{st} and 2^{nd} plant crop confirmed the same trend. These results are in confirmity with the findings of Arpana and Bhagyaraj (2007) who reported that, the phosphorus along with *G.mosseae* increased the germination percentage.

Ratoon crop also showed significantly higher germination percent (90.2) with cane trash plus mycorrhizae (M_3) when compared to cane trash alone (M_4) and control (M_1). However, the treatment receiving mycorrhizae alone (M_2) and combination of cane trash plus mycorhizae were at a par. Significantly, lower germination was recorded with control (84.4%). These results are in agreement with the results of Kelly *et al.*, (2004) who reported that mycorrhizal inoculation was more advantageous in obtaining healthy vigorous seedlings and resulted in higher biomass. The interactions were not found significant during germination stage during study period.

Dry matter production

At all the three stages, the mean drymatter produced across the cane trash and mycorrhizal treatment was significantly higher at inorganic P level of 50 kg P_2O_5 ha^{-1} with corresponding values of 32.4, 40.2 and 37.8 t ha^{-1}. The presence or absence of cane trash or mycorrhizae also found to influence the dry matter production. The presence of both cane trash and mycorrhizae resulted in a significant increase in drymatter of the crop, the values being 36.7, 43.2 and 39.1 t ha^{-1} respectively at formative, grand growth and maturity stages as against 25.8, 33.0 and 31.3 t ha^{-1} in the absence of both at the respective stages at all the three stages. Individual application of mycorrhizae was found to have an edge over cane trash. The interaction effect in presence or absence of cane trash and mycorrhizae on inorganic P was not found significant at all the three stages. Similar response of sugarcane to the levels of inorganic P in presence or absence of cane trash and mycorrhizae was observed in 2^{nd} plant crop with significantly higher mean dry matter when inorganic P was applied at 50 kg P_2O_5 ha^{-1}, and when cane trash and mycorrhizae were integrated.

However, in the ratoon crop, the treatment receiving inorganic P @ 50 and 100 kg P_2O_5 ha^{-1} were at par in producing drymatter both at formative stage and at maturity. The lower root colonization in ratoon crop when compared to plant crops resulted in a low mobilization and exploitation of native P and hence response was observed upto a higher level of inorganic P application @ 100 kg P_2O_5 ha^{-1}. The results are in line with the findings of Matin *et al.*, (2003). The application of phosphorus increased the drymatter production as it played a major role in the absorption and translocation of nutrients from the soil to the canopy. This also might be due to the better growth of plants and better uptake of nutrients. The increase in drymatter production might be due to the improved foraging ability, higher nutrient availability and uptake of nutrients with better assimilation. These results are in agreement of the findings of Devi *et al.*, (2005) who stated that application of 75 percent recommended dose of P_2O_5 on sandy loam soil recorded higher drymatter production when compared to recommended dose of fertilizer. Chen *et al.*, (2003) reported that increased levels of phosphorus increased the shoot biomass and phosphorus content and higher total root length and more fine roots which were beneficial to P uptake by the plants. The same was reported by Sujan Singh (2003) that shoot dry weight increased with increase in rate of P application.

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on germination percentage in 1st and 2nd plant crops and pooled data for 2 years

Treatments	1st plant crop					2nd plant crop					Pooled data for 2 years				
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
M_1	73.0	74.3	75.3	77.0	74.9	74.6	77.5	78.6	78.9	77.3	73.7	75.9	76.8	77.9	76.1
M_2	87.0	88.3	90.0	90.7	89.0	85.2	89.2	91.4	92.1	89.5	86.1	88.7	90.7	91.4	89.2
M_3	85.0	89.6	92.7	93.1	94.1	87.3	92.3	93.6	94.1	91.8	86.1	91.0	93.1	93.6	92.9
M_4	79.4	80.0	81.2	84.0	81.2	83.1	87.2	90.1	93.2	88.4	81.2	83.6	85.6	88.6	84.8
Mean	81.1	82.5	83.7	85.3	83.1	82.6	86.6	88.4	89.6	86.8	81.8	84.5	86.0	87.4	84.9
		S.E.d	**CD at 0.05**	**CV %**			**SEd**	**CD at 0.05**	**CV %**			**SEd**	**CD at 0.05**	**CV %**	
M		3.30	7.95				3.35	8.05				3.12	6.23		
P		0.47	NS				0.49	NS				0.52	1.12		
P x M		6.35	NS				3.45	NS				6.78	13.65		
M x P		0.95	NS				1.05	NS				1.12	2.24		

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on germination percentage in ratoon crop

Treatments	Ratoon crop				
	P_0	P_1	P_2	P_3	Mean
M_1	82.3	83.3	84.2	87.9	84.4
M_2	84.3	88.9	89.3	90.2	88.2
M_3	86.9	89.2	91.2	93.8	90.2
M_4	84.7	87.1	88.3	91.2	87.8
Mean	84.6	87.1	88.2	90.8	83.1
		SEd	**CD**	**CV(%)**	
M		0.23	0.56		
P		0.22	NS		
P x M		0.44	NS		
M x P		0.44	NS		

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on D.P (t ha^{-1}) at different stages in 1st plant

Treatments	1st plant crop					2nd plant crop					Pooled data for 2 years				
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
M_1	21.7	28.4	27.1	26.2	25.8	28.6	35.3	34.5	33.6	33.0	27.5	33.5	32.5	31.6	31.3
M_2	24.3	31.1	29.4	29.2	28.5	31.3	40.5	39.2	38.5	37.4	29.3	37.8	36.6	34.4	34.8
M_3	29.6	40.5	39.3	37.5	36.7	39.5	45.4	44.4	43.6	43.2	32.7	42.6	41.6	39.6	39.1
M_4	23.5	29.5	28.2	26.6	26.9	30.4	39.6	39.2	38.3	36.9	29.5	37.2	34.6	33.7	33.7
Mean	25.1	32.4	31.5	29.9	29.7	32.4	40.2	39.3	38.5	37.6	29.7	37.8	36.3	34.5	34.6
		S.E.d	**CD at 0.05**	**CV %**			**SEd**	**CD at 0.05**	**CV %**			**SEd**	**CD at 0.05**	**CV %**	
M		0.36	0.72	5.6			0.24	0.57	5.2			0.36	0.88	6.2	0.36

P		0.57	1.14				0.27	0.56				0.32	0.65		0.57
P x M		1.72	NS				0.53	NS				0.65	NS		1.72
M x P		1.14	NS	4.2			0.55	NS	4.8			0.63	NS	5.3	1.14
D.P : Dry matter															

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on D.P (t ha^{-1}) at different stages in 2nd plant

Treatments	**1st plant crop**					**2nd plant crop**					**Pooled data for 2 years**				
	P_0	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**
M_1	20.8	27.5	26.1	25.1	24.9	27.5	33.3	33.0	32.6	31.7	25.5	31.5	30.6	32.5	30.0
M_2	23.3	30.0	28.4	28.2	27.5	30.2	39.5	38.2	37.4	36.3	27.3	35.6	33.4	36.6	33.2
M_3	28.3	39.2	38.2	36.5	35.5	38.5	44.4	43.4	42.5	42.2	31.7	40.5	38.5	41.7	38.1
M_4	22.4	28.4	27.1	25.6	25.8	29.4	38.6	38.2	37.1	35.8	28.5	35.5	32.6	36.1	33.2
Mean	23.7	31.3	29.9	28.8	28.4	31.4	38.9	38.3	37.4	36.5	28.2	35.8	33.8	36.7	33.6
			SEd	**CD**	**CV%**			**SED**	**CD**	**CV %**			**SED**	**CD**	**CV %**
M			0.24	0.48	6.7			0.23	0.56	5.6			0.35	0.80	6.2
P			0.16	0.32				0.25	0.55				0.31	0.65	
P x M			0.45	NS				0.51	NS				0.65	NS	
M x P			0.32	NS	4.2			0.54	NS	4.8			0.63	NS	5.4
D.P : Dry matter															

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on D.P (t ha^{-1}) in ratoon crop.

Treatments	**1st plant crop**					**2nd plant crop**					**Pooled data for 2 years**				
	P_0	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**
M_1	22.4	30.3	29.5	28.3	25.0	29.7	36.7	36.3	35.7	34.6	28.6	34.5	33.6	32.7	32.4
M_2	23.4	32.5	31.5	30.4	32.1	32.1	41.5	40.2	39.7	38.4	30.4	38.7	37.7	35.5	35.6
M_3	31.6	38.3	37.4	36.6	36.0	40.3	45.9	45.5	44.2	44.0	33.8	44.1	43.4	42.2	40.9
M_4	22.7	37.0	35.4	33.2	32.1	31.2	40.6	39.3	38.7	37.5	30.6	36.2	35.5	34.6	34.2
Mean	25.0	34.5	33.4	32.1	31.3	33.3	41.2	40.2	39.6	38.6	30.8	38.1	37.3	35.8	35.5
			SEd	**CD**	**CV%**			**SED**	**CD**	**CV %**			**SED**	**CD**	**CV %**
M			0.38	0.92	4.8			0.40	0.80	6.7			0.54	1.08	5.6
P			0.39	0.81				0.38	0.79				0.45	0.90	
P x M			0.78	NS				0.80	NS				1.08	NS	
M x P			0.79	NS	4.3			0.76	NS	5.3			0.90	NS	4.7
D.P : Dry matter															

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on sheath moisture (%) in plant crop

Treatments	**1st plant crop**					**2nd plant crop**					**Pooled data for 2 years**				
	P_0	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**
M_1	80.2	82.6	81.6	81.2	81.4	78.2	81.1	80.4	80.8	80.4	73.5	76.2	75.2	74.3	74.8
M_2	81.7	83.7	84.0	82.8	83.1	79.6	83.1	82.8	82.4	82.0	77.5	79.5	79.5	78.9	78.9

M_3	82.6	84.3	84.6	84.2	83.9	80.4	83.6	83.1	82.8	82.5	78.5	79.6	78.7	79.6	79.1
M_4	81.2	82.4	82.8	82.6	82.3	80.3	83.8	83.2	83.2	82.7	76.3	78.4	78.5	77.8	77.8
Mean	81.4	83.3	83.2	82.7	82.7	79.9	83.2	82.4	82.1	81.9	76.4	78.4	77.9	77.6	77.6
			SEd	**CD**	**CV%**			**SED**	**CD**	**CV %**			**SED**	**CD**	**CV %**
M			0.13	0.26	4.3			0.11	0.22	4.9			0.08	0.19	3.8
P			0.12	NS				0.11	0.22				0.08	0.16	
P x M			0.26	0.52				0.23	0.46				0.16	0.33	
M x P			0.24	0.48	3.2			0.23	0.45	4.2			0.16	0.35	2.4

Effect of different levels of phosphorus in presence and absence of cane trash and mycorrhizae on sheath moisture (%) in ratoon crop

Treatments	**1st plant crop**					**2nd plant crop**					**Pooled data for 2 years**				
	P_0	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**	**P_0**	**P_1**	**P_2**	**P_3**	**Mean**
M_1	81.2	82.2	83.6	82.3	82.3	79.9	81.5	81.3	81.2	80.9	75.2	79.2	78.5	75.9	77.1
M_2	82.2	84.5	84.0	82.8	83.3	79.9	82.5	82.2	82.2	81.7	78.1	80.2	79.4	79.2	79.2
M_3	83.6	85.2	85.0	85.1	84.7	81.6	83.7	83.3	83.0	82.9	77.1	81.1	81.1	80.9	80.1
M_4	82.2	84.0	83.9	84.5	83.4	80.9	83.1	83.0	83.0	82.5	75.5	78.6	77.7	76.2	77.1
Mean	82.3	84.0	83.8	83.2	83.4	80.6	82.7	82.5	82.2	82.0	76.8	79.9	79.1	78.1	78.4
			SEd	**CD**	**CV%**			**SED**	**CD**	**CV %**			**SED**	**CD**	**CV %**
M			0.08	0.20	4.5			0.47	1.15	3.8			0.31	0.63	4.9
P			0.06	0.13				0.12	0.24				0.32	NS	
P x M			0.14	0.30				0.51	1.22				0.62	NS	
M x P			0.13	0.26	3.6			0.24	0.49	2.8			0.65	NS	3.3

Sheath moisture percentage

The sheath moisture percentage in both plant and ratoon crops was influenced by the application of phosphorus. Significantly the higher mean sheath moisture percentage was recorded in the treatment receiving 50 kg P_2O_5 ha^{-1} i.e 84, 82.7, 79.9 in plant crop and 83.3, 78.4 in ratoon crop at formative, grand growth and at maturity stages respectively. However, such influence was not found beyond the application of 50 kg P_2O_5 ha^{-1} at all stages of both plant and ratoon. Mean sheath moisture content (%) was found to decreasing from 89.4 at formative stage to 78.4 at maturity stage in the plant crop and from 82.7 to 77.6 in ratoon crop. During both the years of study, significantly higher mean sheath moisture was observed with the application of both cane trash and mycorrhizae (84.7, 82.9, 80.1) in plant crop (83.9, 82.5 and 78.9) in ratoon crop. The significantly lower sheath moisture was observed with the control not receiving cane trash and mycorrhizae across inorganic P levels (82.3, 80.9, 77.1%) in plant crop and in ratoon crop (81.4, 80.4, 74.8%) respectively at the three stages of growth.

The interaction between inorganic P levels with cane trash and mycorrhizae was found significant. In the absence of cane trash and mycorrhizae, the sheath moisture percent increased significantly with the application of P_2O_5 upto 100 kg P_2O_5 ha^{-1} (83.6%), while in the presence of either mycorrhizae or cane trash or both, the moisture content was significantly higher when inorganic P was applied at 50 kg P_2O_5 ha^{-1}. Similar interaction was found at other stages of plant crop and in ratoon crop. Significantly higher sheath moisture content was recorded when inorganic P @ 50 kg P_2O_5 ha^{-1} was applied in presence of both cane trash and mycorrhizae. The same results were in confirmity with the findings of Lakshmikantham *et al.* (1970).

The moisture content of the sheath is an indication of how best the plant is supplied with nutrients. Addition of inorganic P will facilitate the development of extensive root system for exploiting moisture content from deeper layers. The effect would have further increased by the combined use of cane trash and mycorrhizae might have helped in increasing the absorption surface area for absorption of water and cane trash might have favoured the mycorrhizal growth by optimizing the soil temperature.

REFERENCE

1. Arpana, J and Bhagyaraj, D.J 2007. Response of kalmeg to an arbuscular mycorrhizal fungi and plant growth promoting rhizo micro organisms at two levels of phosphorus fertilizers. *American-Eurasian J Agric. & Environ. Sci.* 2 (1) : 33-38.

2. Kelly, R.M., Edward, D.G., Thompson, P and Magarey, R.C. 2004. Growth responses of sugarcane to mycorrhizal spore density and phosphorus rate. Crop and Pasture science. *Austr. J. Agric. Res.* 56 (12) : 1405–1413.
3. Kelly, R.M., Edwards, D.G., Magarey, R.C and Thompson, J.P. 1997. The effects of VAM on the growth and nutrition of sugarcane. *Proc Aust. Soc. Sugarcane Technol.* 19 : 73-79.
4. Devi, T. C., Bharathalakshmi, M., Kumari, M. B. G. S., Naidu, N. V. 2012. Effect of sources and levels of phosphorus with zinc on yield and quality of sugarcane. *Sugar Tech.* 2 (13) : 232-261.
5. Devi, T.C., Rao K.L., Swamy, K.R.L and Raju D.V.N. 2005. Effect of sources and levels of phosphorus with zinc on yield and quality of sugarcane. Thesis submitted to ANGRAU.
6. Chen Lei, Wang ShengFeng., Liu RongLe., Wang Hong. 2003. Changes of root morphology and rhizosphere processes of wheat under different phosphate supply levels. [Chinese]. *Plant Nutrition and Fertilizer Science*, 18 (2): 324-331.
7. Sujan Singh. 2007. Role of mycorrhizae in disturbed lands. Part II soil compaction, soil erosion, soil aggregation and volcanic eruptions. *Mycorrhizae news*. 15 (2) 1-11.
8. Lakshmikantham, M. 1983. Technology of sugarcane growing. Oxford and IBH Limited, New Delhi.