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Effect of subsurface fertigation on chemical properties and nutrient status of soil under sugarcane crop cover

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Abstract
An investigation was carried out to study the effect of subsurface fertigation on fertility status of soil under sugarcane crop cover in Arsapura and Yellebethuru villages of Davangere district, Karnataka during 2015-16. The soil pH and soil organic carbon status under subsurface fertigated sugarcane farms decreases with increasing depth. The soil pH status was neutral to alkali in nature and soil organic carbon ranged from low to medium. A soil were non saline and there was less variation in EC values in farms with depth but were higher at surface layer and lower at subsurface layer. The available nitrogen, phosphorus and potassium in soil showed decreasing trend with depth. The available nitrogen was medium, available P_2O_5 and available K_2O_5 ranged from low to medium. The calcium, magnesium and available sulphur in soil increases with depth and were higher at 45-60 cm and 60-75 cm than surface layer under selected subsurface fertigated farms. The exchangeable calcium, magnesium and available sulphur was sufficient.

Keywords: fertigation, macronutrients, sugarcane

Introduction
Fertigation is a modern technique of application of both water and fertilizers through irrigation is proved to be very effective in achieving higher yield and water use efficiency as these crucial inputs are delivered precisely in the effective crop root zone as per the crop needs and crop developmental stages. Among the nutrient managements subsurface fertigation is one which manage the nutrients in efficiently. Nutrient transport from the soil solution to the root surface takes place by two simultaneous processes: convection in the water flow (mass flow) and diffusion along the concentration gradient (Barber, 1995; Jungk, 1996) [3, 11]. Soil properties, crop characteristics and growing conditions affect the relative importance of each mechanism, but the general situation is that the mobile ions supply is taken up mainly through mass flow while for less mobile elements such as P and K, diffusion is the governing mechanism (Nye and Tinker, 1977; Classen and Steingrobe, 1999 and Mmolawa and Or, 2000) [14, 6, 13]

Sugarcane (*Saccharum officinarum* L.) being a giant crop, producing huge quantity of biomass, generally demands higher amount of nutrient elements. A large number of research experiments have clearly demonstrated that for producing higher cane and sugar yield on a sustainable basis, the balance amount of nutrients application is very important. Subsurface fertigation is an advanced production technique using in sugarcane to increase yield. The supply of fertilizers nutrients along with irrigation water through the drippers are installed in subsurface soil depth (below 15 cm depth), to increase the nutrients and water use efficiency and ultimately achieve the higher production in sugarcane crops.

Material and Methods
Six farmers field from Arsapura and Yellebethuru villages in Davangere district practicing subsurface fertigation in sugarcane crop for more than 2 years were selected. In study area the farmers are using CO - 323 and CO –265 varieties of sugarcane crop under subsurface fertigation. The application of 50 kg of Urea, 45 kg of 17-17-17 NPK, 45 kg of Diammonium phosphate (DAP) and 40 kg of Sulphate of potash (SOP) fertilizer for each acre were used in three split for sub surface fertigation. Additional quantity of 6 kg of fertilizers was given at 15 days interval in solution forms. Farms were irrigating one hour per acre per day. Sugarcane grown in paired row system with recommended spacing of row to row 180 cm and lateral to lateral 150cm with Tunga canal water. The ninty soil samples were collected from 0-15, 15-30, 30-45, 45-60 and 60- 75 cm soil depth. In each farm depth wise three soil samples (total 15) in

one acre area from 15 cm distance from lateral to row were collected from both the villages after harvest of sugarcane. Soil samples were analysed using standard procedure. Particle size distribution was determined by international pipette method (Piper, 1966) [15]. Soil pH and EC was determined 1:2.5 soil to water suspension by potentiometric and conductometric methods respectively (Jackson, 1973) [10]. The organic carbon in soil (0.2mm sieved) was determined by wet oxidation method (Walkley and Black, 1934) [21].

Available nitrogen in the soil was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956) [18]. Available phosphorus and available potassium was determined by spectrometer and flame photometer (Jackson, 1973) [10]. The exchangeable calcium and magnesium were determined by Versenate titration method (Jackson, 1973) [10]. Available sulphur was extracted from soil using 0.15 per cent calcium chloride solution and determined turbidimetrically as described by Black (1965) [5].

Results and Discussion

Soil reaction (pH)

The soil pH status under selected sugarcane subsurface fertigated farms recorded a decreasing trend with depth (Table 1 and 2). The pH was more at 0-15 cm and lower at 60-75 cm. This may be due to the fertigated with complex fertilizer and broadcast on the plots with ammonium nitrate. The pH was lower in a large area where the soil was wet and the application of nutrients by fertigation with complete fertilizer decreased soil pH directly under the drippers (Waldemar Treder, 2005) [20]. Continuous application of organic manures alone or in conjunction with NP fertilizers for 10 years decreased the soil pH (Antil and Mandeep, 2007) [2].

Electrical conductivity

The data on soil EC values under fertigated sugarcane farms was higher 0-15 cm depth and lower at 60-75 cm soil depth in all farms of Arsapura and Yellebethuru village(Table 1 and 2). Douglas *et al.* (2014) [8] reported that greater storage of salts was coming from the drip zone and possessed a distribution gradient with the highest concentration near the emitter and lowest near the wetting front in sugarcane crop.

Soil organic carbon

The result of organic carbon content of soil was decreased with increase in depth under selected sugarcane subsurface fertigated farms. The soil organic carbon was higher at 0-15 cm soil depth in all farms of Arsapura and Yellebethuru village and lower at 45-60 cm and 60-75 cm soil depth(Table 1 and 2). This might be due to the continuous addition of sugarcane biomass deposition at surface layer. Regular addition of organic manure could improve soil organic content of soil profile even up to 60 cm as reported by Srinivas rao *et al.* (2007) [17].

Macronutrient status

Available N, P_2O_5 and K_2O

The available nitrogen content of soil under selected sugarcane subsurface fertigated farms, was higher at surface soil (0-15 cm) and lower at subsurface soil (45-60 cm) in all farms of Arsapura and Yellebethuru village (Table 3 and 4).There was decreasing trend in available nitrogen with increasing depth might be due to the sandy clay loam texture and continuous addition of sugarcane biomass deposition at surface layer. The available N content was confined to maximum at immediately below the emitter and moved laterally up to 15 cm and vertically up to 15-25 cm and thereafter dwindled. The nitrogen content in the soil profile neither accumulates at the periphery of the wetting front nor leached from the root zone as reported by Anitta Fanish and Muthukrishnan (2013) [1]. In the top soil layer, soil N availability is high, and rapid nitrification rates lead to the accumulation of large NO_3 pools that are susceptible to leaching (Jackson and Bloom, 1990) [9]. Cote *et al.* (2003) [7] reported that in highly permeable coarse-textured soil water and nutrients move quickly downward from the emitter. Available N content was found to be maximum in surface horizons and decreased regularly with soil depth which might be due to accumulation of biomass in the surfacelayer leading to higher N content in surface layer than subsurface layer. These results were in line with the findings of Setia and Sharma (2004) [16].

The available phosphorus content of soil decreases with depth (Table 3and 4), higher at surface layer and lower at subsurface layer might be due to less mobile in nature,high organic matter and more uptake. A spectacular movement of phosphorus in the soil was found under drip fertigation. The extend movement of orthophosphate from the emitter is very much dependent upon the phosphate adsorption of the soil (Anitta Fanish and Muthukrishnan, 2013) [1].

The results on available potassium content of soil was higher at surface soil (0-15 cm) and lower at subsurface soil (60-75 cm) (Table 3and 4) might be due to the sandy clay loam in texture at surface layer. The available K content was maximum in the surface layer due to entrance of K ions on soil exchange complex resulting in very small movement to deeper layer and majority of applied K was held in the surface soil and the downward movement was low (Suganya *et al.,* 2007) [19].

Exchangeable calcium, magnesium and available sulphur

In farm 1 and 2 of Arsapura village, the available calcium was higher at 45-60 cm; in farms 3, 4, 5 and 6 of Yellebethuru village, the available calcium was higher at 60-75 cm(Table 3and 4). This might be due to differential weathering of parent material and rise of capillary water.

In farms 1, 4, 5, and 6 of Arsapura and Yellebethuru village, the exchangeable magnesium was recorded higher at 60-75cm (Table 3and 4). In farm 2 and 3 of Arsapura village, the available magnesium recorded higher at 45-60 cm, might be due to leaching loss. Leaching of magnesium under the dripper alsooccurred when urea was applied (Belton and Goh, 1992) [4]. Fertigation with ammonium nitrate caused leaching of magnesium directly underneath the dripper and accumulated at 40-60 cm from the dripper (Komosa *et al.*, 1999) [12].

In farms 1, 3 and 6 of Arsapura and Yellebethuru village, the available sulphur was recorded higher at 60-75 cm (Table 3and 4). In farms 2, 4 and 5 of Arsapura and Yellebethuru village, the available sulphur is higher at 45-60cm, might be due to the more leaching, negative ion and rate of downward movement.

Table 1: Effect of subsurface fertigation under sugarcane crop cover on depth wise distribution of chemical properties Arsapura village of Davangere district

Depth(cm)	pH	EC(dSm^{-1})	OC($g\ kg^{-1}$)
Farm 1			
0-15	8.87	0.30	5.7
15-30	8.81	0.27	4.0
30-45	8.19	0.25	4.1
45-60	8.78	0.25	3.6
60-75	7.47	0.24	2.3
Farm 2			
0-15	7.97	0.30	5.1
15-30	7.77	0.28	5.0
30-45	7.76	0.27	4.9
45-60	7.89	0.24	4.0
60-75	7.68	0.21	3.6
Farm 3			
0-15	8.10	0.29	4.9
15-30	8.03	0.28	4.4
30-45	7.63	0.26	4.0
45-60	7.59	0.27	4.6
60-75	7.54	0.25	3.9

Table 2: Effect of subsurface fertigation under sugarcane crop cover on depth wise distribution of chemical properties in Yellebethuru village of Davangere district

Depth (cm)	H	EC(dSm-1)	OC (g kg-1)
Farm 4			
0-15	8.87	0.30	5.7
15-30	8.81	0.27	4.0
30-45	8.19	0.25	4.1
45-60	8.78	0.25	3.6
60-75	7.47	0.24	2.3
Farm 5			
0-15	7.97	0.30	5.1
15-30	7.77	0.28	5.0
30-45	7.76	0.27	4.9
45-60	7.89	0.24	4.0
60-75	7.68	0.21	3.6
Farm 6			
0-15	8.10	0.29	4.9
15-30	8.03	0.28	4.4
30-45	7.63	0.26	4.0
45-60	7.59	0.27	4.6
60-75	7.54	0.25	3.9

Table 3: Effect of subsurface fertigation under sugarcane crop cover on depth wise distribution of macronutrients in Arsapura village of Davangere district

Depth (cm)	Available N	Available P_2O_5	Available K_2O	Exchangeable Ca	Exchangeable Mg	Available S
	Kg ha^{-1}			cmol(p+)kg^{-1}		mg kg^{-1}
Farm 1						
0-15	393.64	36.96	466.60	6.17	5.61	3.12
15-30	368.67	31.10	390.02	6.20	5.30	3.45
30-45	327.97	28.63	323.70	6.20	5.47	3.91
45-60	350.40	27.00	335.14	7.62	6.45	3.97
60-75	322.04	25.63	314.98	6.67	7.68	4.20
Farm 2						
0-15	381.98	35.21	440.42	6.08	5.40	3.63
15-30	366.62	32.11	438.29	6.98	5.45	4.30
30-45	344.98	31.45	397.46	6.67	5.93	4.41
45-60	327.76	26.78	418.21	7.47	6.00	4.58
60-75	321.87	26.87	382.50	6.62	5.48	4.03
Farm 3						
0-15	387.64	36.74	413.95	7.15	5.50	4.07
15-30	350.36	33.83	415.24	6.34	5.73	3.41
30-45	336.57	27.76	379.90	7.92	7.35	3.89
45-60	323.69	23.63	367.68	8.62	7.90	3.53
60-75	322.17	23.52	346.84	9.02	7.53	4.45

Table 4: Effect of subsurface fertigation under sugarcane crop cover on depth wise distribution of macro nutrients in Yellebethuru village of Davangere district

Depth (cm)	Available N	Available P_2O_5	Available K_2O	Exchangeable Ca	Exchangeable Mg	Available S
	Kg ha^{-1}			cmol(p+)kg^{-1}		mg kg^{-1}
Farm 4						
0-15	381.31	39.74	418.16	6.95	6.41	3.26
15-30	378.96	35.33	382.03	7.68	6.54	3.68
30-45	363.53	31.31	376.97	7.50	7.39	3.48
45-60	329.84	23.42	345.73	7.71	7.28	4.96
60-75	326.26	22.58	312.88	8.44	7.83	4.08
Farm 5						
0-15	347.80	37.00	345.73	6.89	6.14	4.59
15-30	336.19	33.14	329.82	7.00	7.03	5.19
30-45	320.40	32.75	327.07	7.12	6.82	5.14
45-60	303.18	31.76	321.30	7.03	6.20	5.41
60-75	298.46	22.58	304.92	8.44	7.39	5.08
Farm 6						
0-15	387.73	38.01	348.81	6.49	6.03	4.28
15-30	376.82	35.47	340.54	6.57	6.49	4.00
30-45	371.77	36.28	332.22	7.04	6.38	5.05
45-60	336.80	34.99	339.90	7.50	7.28	4.72
60-75	317.22	34.59	317.53	8.60	8.13	5.55

Conclusion

The study on effect of subsurface fertigation on fertility status of soil under sugarcane crop cover in Arsapura and Yellebethuru villages showed that the soil pH and soil organic carbon decreases with increasing depth. There was less variation in EC values in farms with depth. The available nitrogen, phosphorus and potassium in soil showed decreasing trend with depth. The calcium, magnesium and available sulphur in soil increases with depth and were higher at 45-60 cm and 60-75 cm than surface layer under selected subsurface fertigated farms.

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