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CHANGES IN PHYSICO CHEMICAL PROPERTIES OF PADDY SOIL UNDER DIFFERENT LEVELS OF FERTIGATION AND IRRIGATION

[1]Krishna Murthy, R., [1]Balaji Naik, D. [1]Ningaraju, G.K. & [2]Pushpa, K.
[1] Soil and Water Management Zonal Agricultural Research Station, V.C. Farm, Mandya – 571 405
[2]Department of Agronomy, College of Agriculture, V.C. Farm, Mandya – 571 405
Corresponding author: e-mail:srkmurthyssac@gmail.com

ABSTRACT
A field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya during *Kharif* 2014 to study the changes in physico chemical properties of paddy soil as influenced by different levels of fertigation and irrigation. Among the different levels of irrigation and drip fertigation, irrigation @150 % CPE + DF 125 % RDF recorded significantly higher soil reaction (6.85, 6.84, 6.86 and 6.77 at 30, 60, 90 DAS and at harvest respectively) followed by irrigation @125 % CPE + DF 125 % RDF (6.80, 6.78, 6.80 and 6.73, respectively. Irrigation @150 % CPE + DF 125 % RDF recorded significantly highest organic carbon (0.50, 0.49, 0.50 and 0.52 g kg^{-1}, respectively) as compared to irrigation @100 % CPE + DF 75 % RDF (0.40, 0.41, 0.41 and 0.42 g kg^{-1}). Available nitrogen, phosphorus and potassium in soil between 30 DAS to harvest varied significantly with different levels of irrigation and drip fertigation. At harvest irrigation@150 % CPE + DF 125 % RDF recorded significantly higher available nitrogen, phosphorus and potassium content (325.48, 55.33 and 246.48 kg ha^{-1}, respectively) as compared to irrigation @100 % CPE + DF 75 % RDF (272.00, 24.50 and 201.67 kg ha^{-1}, respectively). At harvest significantly higher exchangeable calcium, magnesium and available sulphur (6.01, 2.23 cmol kg^{-1} and 12.90 mg kg^{-1}, respectively) was recorded in irrigation @150 % CPE + DF 125 % RDF, when compared to irrigation @100 % CPE + DF 75 % RDF (4.92, 1.63 cmol kg^{-1} and 8.87 mg kg^{-1} respectively). Between 30 DAS to harvest, DTPA manganese, iron, copper, zinc and boron in soil did not vary significantly among different levels of irrigation and drip fertigation

KEY WORDS: Drip, Fertigation, Cumulative pan evaporation, Soil moisture, Nutrient

INTRODUCTION
Rice (*Oryza sativa* L.) is the leading cereal of the world and more than half of the human race depends on rice for their daily sustenance. Rice consumes 5000 liters of water to produce one kg of grain, which is three times higher than other cereals. Rice is a semi- aquatic plant and the farmers are habituated to irrigate as much water as possible through continuous land submergence based on a wrong notion that yield could be increased with increased water use. Traditional rice production system not only leads to wastage of water but also causes environmental problems and reduces fertilizer use efficiency. Fertilizer application in wetland rice farming is currently done manually through the soil application in split doses. The technique employed is imprecise and causes problems such as fluctuating nutrient supply and uneven fertilizer spread and it is labour intensive, thus leading to various losses of nutrients under submerged cultivation. Besides loss of water and fertilizers through seepage and percolation, impounding water in paddy fields has an important environmental impact by contributing to global warming through considerable emission of methane.

MATERIALS & METHODS
Study site
Field experiment was conducted during *Kharif* 2014 at Zonal Agricultural Research Station, (ZARS), V. C. Farm, Mandya, Southern Dry Zone (Zone – 6) of Karnataka. The experimental site is located between 12º 51' and Latitude and 77º 35' E Longitude at an altitude of 930 m above mean sea level (MSL). The experiment was laid out in randomized complete block design with ten treatments *viz* three levels of irrigation based on 100, 125 and 150 % cumulative pan evaporation in combination with 75, 100 and 125 % recommended dose of fertilizer compared with conventional puddled transplantation. The drip line was passed in between two consecutive rows by skipping one row alternatively and laterals were placed 60 cm apart. Inline emitters were placed 40 cm apart with discharge rate of 4lph. The recommended dosage of fertilizer for paddy is 100N: 50 P_2O_5: 50K_2O per hectare. The calculated quantity of phosphorus was applied to all the treatments through single super phosphate by soil application, whereas nitrogen and potassium were supplied through drip in equal splits, starting from 15 days after sowing up to 10 days before harvest using water soluble urea and muriate of potash, respectively. The quantity of water to be irrigated was calculated based on daily pan evaporation and irrigated in four days once. At 30, 60, 90 DAS and at harvest soil samples were collected and analyzed for physico chemical properties using standard procedures.

RESULTS & DISCUSSION

Initial physico-chemical properties of the soils

Soil selected for the conduct of experiments had diverse physico-chemical properties (Table 1). Texture of the soil is sandy loam with more sand and silt (53.4 and 16.6 % respectively) and it is neutral with a pH value of 6.88. The organic carbon content was 0.47 g kg^{-1}, available nitrogen content (255.30 kg ha^{-1}), available phosphorus (28.50 kg ha^{-1}) and available potassium (170.69 kg ha^{-1}). Secondary nutrients like exchangeable Ca and Mg are 2.48 and 1.87 (cmol kg^{-1}) respectively. Available sulphur (11.25 mg kg^{-1} soil), DTPA extractable Fe, Mn, Zn, Cu and hot water soluble boron are 11.85, 9.85, 0.84, 0.97 and 0.89 mg kg^{-1} respectively.

TABLE 1: Physical and chemical properties of soil in the experimental site

Particulars	Values
I. Physical properties	
1. Coarse sand (%)	53.4
2. Fine sand (%)	14.8
3. Silt (%)	16.6
4. Clay (%)	15.2
5. Textural class	Sandy loam
II. Chemical properties	
1. pH (1:2.5)	6.88
2. EC (1:2.5) (dSm^{-1})	0.35
3. Organic carbon (g kg^{-1})	0.47
4. Available N (kg ha^{-1})	255.30
5. Available P_2O_5 (kg ha^{-1})	28.50
6. Available K_2O (kg ha^{-1})	170.69
7.Exch. Ca (cmol kg^{-1})	2.48
8.Exch. Mg (cmol kg^{-1})	1.87
9. Available. S (mg kg^{-1})	11.25
10.DTPA Mn (mg kg^{-1})	9.82
11.DTPA Fe (mg kg^{-1})	11.85
12.DTPA Zn (mg kg^{-1})	0.84
13.DTPA Cu (mg kg^{-1})	1.97
14. Available B (mg kg^{-1})	0.89

Changes in physico chemical properties of soil under different stages of crop growth

Among the different levels of irrigation and drip fertigation, (T_9) irrigation @150 % CPE + DF 125 % RDF recorded significantly higher soil reaction (6.85, 6.84, 6.86 and 6.77 at 30, 60, 90 DAS and at harvest respectively) (Table.2), followed by (T_8) irrigation @125 % CPE + DF 125 % RDF (6.80, 6.78, 6.80 and 6.73, respectively). However, (T_1) irrigation @100 % CPE + DF 75 % RDF recorded significantly lower soil reaction (6.36, 6.35, 6.36 and 6.34 at 30, 60, 90 DAS and at harvest, respectively). The increase or decrease in pH during crop growth period over time in the study may be attributed by a process of shift in H^+/OH^- during drying and wetting of soil. The rise in pH may be due to accumulation of basic cations like calcium, magnesium and potassium during mineralization of organic matter (Sarlakumari, 2014). Sudhir and Siddaramappa (1995) indicated a decrease in pH under aerobic condition when fertilizers are applied.

Significantly higher electrical conductivity (0.31, 0.29, 0.34 and 0.32 dSm^{-1}, respectively) was noticed with (T_9) irrigation @150 % CPE + DF 125 % RDF (Table 2). However, (T_1) irrigation @100 % CPE + DF 75 % RDF registered lower electrical conductivity (0.21, 0.19, 0.21 and 0.19 dSm^{-1}, respectively). The changes in conductance reflect the balance between reactions that produce ions and those that inactivate them or replace them with other moving ions (Ponnamperuma, 1975, Katyal, 1977 and Krishna Murthy, 2006). Decline in electrical conductivity towards harvest might be due to drop in water-soluble ions after tillering stage, which otherwise contribute to the electrical conductivity.

At all growth stages organic carbon varied significantly among all the treatments. (T_9) irrigation @150 % CPE + DF 125 % RDF (Table 2) recorded significantly higher organic carbon (0.50, 0.49, 0.50 and 0.52 g kg^{-1}, respectively) as compared to (T_1) irrigation @100 % CPE + DF 75 % RDF (0.40, 0.41, 0.41 and 0.42 g kg^{-1}). The decrease in organic carbon during growth stages might be due to mineralization of organic matter in the soil over a period of time (Bharadwaj and Omanwar, 1994). Available nitrogen, phosphorus and potassium in soil between 30 DAS to harvest varied significantly with different levels of irrigation and drip fertigation. At harvest (T_9) irrigation @150 % CPE + DF 125 % RDF recorded significantly higher available nitrogen, phosphorus and potassium content (325.48, 55.33 and 246.48 kg ha^{-1}, respectively) (Table.3) as compared to (T_1) irrigation @100 % CPE + DF 75 % RDF (272.00, 24.50 and 201.67 kg ha^{-1}, respectively). Nutrient availability had shown declining trend at later stages while, the uptake was progressively and significantly increased throughout the crop growth period with different treatments (Krishna Murthy *et al.*, 2009). Guled (1993) reported that maintaining high soil moisture content or higher water potential influenced the better root development and nutrient uptake. Similarly, Ladha *et al.* (1998) had also reported that larger root system with greater increase in root surface area, which increased the nutrient uptake.

TABLE 1: Changes in pH, electrical conductivity and organic carbon of soil at different stages of crop growth as influenced by levels of irrigation and drip fertigation

Treatments	pH				EC (dSm^{-1})				OC (g kg^{-1})			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
T_1: I @100 % CPE + DF 75 % RDF	6.36	6.35	6.36	6.34	0.21	0.19	0.21	0.19	0.40	0.41	0.41	0.42
T_2: I @125 % CPE + DF 75 % RDF	6.38	6.36	6.38	6.36	0.22	0.20	0.22	0.21	0.41	0.42	0.42	0.42
T_3: I @150 % CPE + DF 75 % RDF	6.52	6.50	6.51	6.48	0.23	0.22	0.23	0.22	0.44	0.43	0.44	0.45
T_4: I @100 % CPE + DF 100 % RDF	6.55	6.51	6.57	6.55	0.24	0.23	0.23	0.23	0.46	0.44	0.45	0.45
T_5: I @125 % CPE + DF 100 % RDF	6.72	6.69	6.71	6.68	0.26	0.25	0.26	0.25	0.48	0.47	0.47	0.47
T_6: I @150 % CPE + DF 100 % RDF	6.78	6.75	6.77	6.73	0.27	0.26	0.27	0.26	0.48	0.48	0.48	0.48
T_7: I @100 % CPE + DF 125 % RDF	6.68	6.67	6.69	6.67	0.26	0.24	0.23	0.24	0.47	0.46	0.47	0.47
T_8: I @125 % CPE + DF 125 % RDF	6.80	6.78	6.80	6.73	0.28	0.27	0.30	0.29	0.49	0.48	0.48	0.49
T_9: I @150 % CPE + DF 125 % RDF	6.85	6.84	6.86	6.77	0.31	0.29	0.34	0.32	0.50	0.49	0.50	0.52
T_{10}: Conventional method	6.47	6.42	6.49	6.45	0.22	0.22	0.22	0.21	0.42	0.43	0.43	0.44
S.Em ±	0.03	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
CD @ 5 %	0.08	0.03	0.06	0.07	0.03	0.02	0.03	0.03	0.06	0.02	0.02	0.02

I: Irrigation **CPE:** Cumulative pan evaporation **DF:** Drip fertigation **RDF:** Recommended dose of fertilizers **DAS:** Days after sowing

TABLE 2: Changes in available nitrogen, phosphorus and potassium nutrient of soil at different stages of crop growth as influenced by levels of irrigation and drip fertigation

Treatments	Av. N (kg ha^{-1})				Av.P_2O_5 (kg ha^{-1})				Av.K_2O (kg ha^{-1})			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
T_1: I @100 % CPE + DF 75 % RDF	214.00	210.67	204.74	172.00	21.73	20.67	20.33	20.23	208.33	206.00	204.67	201.67
T_2: I @125 % CPE + DF 75 % RDF	219.00	216.00	212.00	177.29	22.67	21.13	21.10	21.06	214.67	212.00	208.33	205.33
T_3: I @150 % CPE + DF 75 % RDF	225.67	223.00	219.00	197.67	25.83	22.17	22.00	21.50	221.83	217.58	214.17	211.67
T_4: I @100 % CPE + DF 100 % RDF	227.00	224.33	219.67	198.40	25.57	24.00	23.00	22.67	232.20	227.67	221.00	212.77
T_5: I @125 % CPE + DF 100 % RDF	235.33	233.33	224.40	211.00	26.33	24.67	24.50	24.35	239.00	232.87	227.13	217.58
T_6: I @150 % CPE + DF 100 % RDF	242.00	241.00	225.71	215.40	27.40	26.33	25.67	25.27	244.00	239.33	232.67	222.74
T_7: I @100 % CPE + DF 125 % RDF	234.00	232.00	222.67	199.83	25.73	24.33	24.00	23.53	236.13	231.29	225.67	215.13
T_8: I @125 % CPE + DF 125 % RDF	246.33	236.00	227.83	219.40	28.63	28.33	28.00	27.57	255.40	251.20	248.21	239.88
T_9: I @150 % CPE + DF 125 % RDF	252.33	246.33	231.67	225.48	31.20	30.50	30.33	30.06	264.80	258.50	252.38	246.48
T_{10}: Conventional method	224.67	221.67	214.67	185.74	23.33	23.29	22.17	21.50	218.60	214.33	211.00	209.00
S.Em ±	1.20	1.35	1.23	1.48	1.03	0.68	0.42	0.36	1.15	1.03	0.90	1.05
CD @ 5 %	3.75	4.10	3.73	4.51	3.10	2.08	1.03	1.10	3.42	3.05	2.66	3.13

I: Irrigation **CPE:** Cumulative pan evaporation **DF:** Drip fertigation **RDF:** Recommended dose of fertilizers **DAS:** Days after sowing

TABLE 3: Changes in exchangeable calcium, magnesium and available sulphur of soil at different stages of crop growth as influenced by levels of irrigation and drip fertigation

Treatments	Exch.Ca (cmol kg^{-1})				Exch. Mg (cmol kg^{-1})				Av. S (ppm)			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
T_1: I @100 % CPE + DF 75 % RDF	5.10	4.98	4.95	4.92	1.69	1.67	1.65	1.63	9.24	9.21	9.17	8.87
T_2: I @125 % CPE + DF 75 % RDF	5.37	5.28	5.23	5.17	1.72	1.70	1.69	1.64	9.41	9.30	9.20	9.07
T_3: I @150 % CPE + DF 75 % RDF	5.64	5.62	5.53	5.52	1.85	1.83	1.80	1.77	10.27	10.23	10.07	10.07
T_4: I @100 % CPE + DF 100 % RDF	5.71	5.69	5.67	5.62	1.87	1.86	1.83	1.81	10.53	10.50	10.17	10.13
T_5: I @125 % CPE + DF 100 % RDF	5.77	5.73	5.72	5.68	1.97	1.96	1.89	1.86	12.28	12.20	11.80	11.40
T_6: I @150 % CPE + DF 100 % RDF	5.94	5.92	5.91	5.87	2.13	2.12	2.07	2.04	12.62	12.57	12.13	11.77
T_7: I @100 % CPE + DF 125 % RDF	5.74	5.72	5.69	5.67	1.94	1.92	1.87	1.83	11.65	11.60	10.87	10.70
T_8: I @125 % CPE + DF 125 % RDF	6.00	5.96	5.93	5.91	2.22	2.18	2.16	2.14	13.15	13.07	12.83	12.47
T_9: I @150 % CPE + DF 125 % RDF	6.21	6.18	6.03	6.01	2.30	2.27	2.25	2.23	13.50	13.46	13.30	12.90
T_{10}: Conventional method	5.62	5.60	5.26	5.23	1.80	1.78	1.76	1.74	9.59	9.52	9.50	9.50
S.Em ±	0.04	0.01	0.05	0.01	0.02	0.04	0.02	0.01	0.02	0.07	0.06	0.06
CD @ 5 %	0.12	0.02	0.15	0.03	0.07	0.12	0.06	0.02	0.06	0.22	0.19	0.18

I: Irrigation **CPE:** Cumulative pan evaporation **DF:** Drip fertigation **RDF:** Recommended dose of fertilizers **DAS:** Days after sowing

TABLE 4: Changes in DTPA extractable manganese, iron, copper, zinc and boron of soil at different stages of crop growth as influenced by levels of irrigation and drip fertigation

Treatments	Mn (mg kg^{-1})				Fe (mg kg^{-1})				Cu (mg kg^{-1})				Zn (mg kg^{-1})				Av. B (mg kg^{-1})			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
T_1: I @100 % CPE + DF 75 % RDF	4.93	4.87	4.67	4.37	7.07	6.80	6.40	6.30	1.29	1.27	1.25	1.22	0.46	0.44	0.42	0.41	0.43	0.41	0.40	0.39
T_2: I @125 % CPE + DF 75 % RDF	5.63	5.57	5.37	5.07	7.60	7.50	7.17	7.20	1.38	1.37	1.34	1.31	0.50	0.49	0.48	0.47	0.48	0.46	0.43	0.42
T_3: I @150 % CPE + DF 75 % RDF	6.80	6.77	6.57	6.27	9.37	9.17	8.93	8.63	1.48	1.46	1.42	1.41	0.56	0.55	0.53	0.52	0.57	0.55	0.53	0.52
T_4: I @100 % CPE + DF 100 % RDF	7.46	7.37	7.17	7.03	9.70	9.67	9.20	9.10	1.58	1.56	1.53	1.51	0.63	0.62	0.61	0.59	0.63	0.62	0.061	0.59
T_5: I @125 % CPE + DF 100 % RDF	8.25	8.17	7.97	7.60	10.66	10.50	10.27	10.13	1.76	1.74	1.72	1.70	0.70	0.68	0.65	0.64	0.67	0.65	0.62	0.61
T_6: I @150 % CPE + DF 100 % RDF	8.55	8.37	8.17	7.97	10.93	10.80	10.50	10.37	1.81	1.78	1.75	1.72	0.72	0.70	0.66	0.65	0.74	0.74	0.71	0.70
T_7: I @100 % CPE + DF 125 % RDF	7.72	7.57	7.37	7.23	9.80	9.70	9.50	9.40	1.66	1.65	1.63	1.62	0.67	0.66	0.65	0.63	0.65	0.64	0.63	0.63
T_8: I @125 % CPE + DF 125 % RDF	8.87	8.77	8.57	8.20	10.83	10.87	10.63	10.50	1.86	1.85	1.83	1.82	0.76	0.73	0.71	0.68	0.85	0.83	0.81	0.80
T_9: I @150 % CPE + DF 125 % RDF	9.72	9.40	9.27	9.00	11.83	11.80	11.27	10.87	1.95	1.94	1.92	1.88	0.81	0.80	0.79	0.76	0.87	0.86	0.84	0.81
T_{10}: Conventional method	6.00	5.93	5.70	5.50	8.80	8.67	8.53	8.30	1.42	1.41	1.40	1.37	0.54	0.54	0.52	0.51	0.53	0.52	0.51	0.49
S.Em ±	0.07	0.04	0.03	0.04	0.04	0.06	0.06	0.08	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.03	0.02	0.03	0.03
CD @ 5%	0.22	0.12	0.10	0.12	0.13	0.18	0.19	0.23	0.03	0.02	0.02	0.02	0.03	0.06	0.03	0.02	0.09	0.05	0.08	0.09

I: Irrigation **CPE:** Cumulative pan evaporation **DF:** Drip fertigation **RDF:** Recommended dose of fertilizers **DAS:** Days after sowing

Between 30 DAS to harvest, exchangeable calcium, magnesium, and available sulphur, varied significantly among different levels of irrigation and drip fertigation in aerobic rice. At harvest significantly higher exchangeable calcium, magnesium and available sulphur (6.01, 2.23 cmol kg^{-1} and 12.90 mg kg^{-1}, respectively) was noticed under (T_9) irrigation @150 % CPE + DF 125 % RDF (Table 4) when compared to (T_1) irrigation @100 % CPE + DF 75 % RDF (4.92, 1.63 cmol kg^{-1} and 8.87 mg kg^{-1} respectively). The exchangeable calcium, magnesium and sulphur decreased gradually from 30 DAS to harvest (Basumantary and Talukdar, 1998 and Lal and Mathur, 1992). The increase in concentration of sulphur may be attributed to the more availability of sulphur in soil due to added inorganic sulphur through zinc sulphate and release of sulphur in organic form.

Between 30 DAS to harvest, DTPA manganese, iron, copper, zinc and boron of aerobic rice in soil did not vary significantly among different levels of irrigation and drip fertigation. At 30 DAS to harvest highest DTPA manganese, iron, copper, zinc and boron was found with (T_9) irrigation @150 % CPE + DF 125 % RDF (9.00, 10.87, 1.88, 0.76 and 0.081 mg kg^{-1}, respectively) (Table.5), as compared to other treatments. However, lowest DTPA manganese, iron, copper, zinc and boron was noticed with (T_1) irrigation @100 % CPE + DF 75 % RDF (4.37, 6.30, 1.22, 0.41 and 0.039 mg kg^{-1} at 30, 60, 90 DAS and at harvest, respectively). DTPA extractable manganese, zinc, iron, copper and boron was decreased throughout the crop growth, this might be due to uptake of nutrients. These findings are corroborated with the findings Indulkar and Malewar, (1990) and Bharadwaj and Omanwar (1994).

The results indicate that nutrient availability in soil decreased from initial value and the trend gradually decreased at different stages of crop growth mainly because of uptake for its growth and development.

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