Int.J.Curr.Microbiol.App.Sci (2018) *7*(12): 3535-3543

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 12 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.712.400

Influence of Drip Fertigation on Physico-Chemical Properties of an Alluvial Soil of West Bengal, India

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A B S T R A C T

The field experiment was conducted at the Central Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, in of West Bengal to study the effect of drip fertigation on the physico-chemical properties viz. pH, electrical conductivity and organic carbon of an alluvial soil and its impact on yield of banana during the year 2012 and 2013. The fertigation was done at four evapotranspiration (ET) based irrigation levels (D_1=0.6 ETo, D_2=0.8 ETo, D_3=1.0 ETo for drip and surface irrigation (S) at IW/CPE 1.0) and at three fertilizer levels of recommended doses of fertilizer (RDF) viz., F_1=60% RDF, F_2=80% RDF and F_3=100% RDF. The experiment was laid out in the factorial randomized block design with three replications. After the fertigation experiment the soil pH decreased with increasing irrigation levels and fertilizer doses, but statistically non-significant. The values obtained were 6.81, 6.77, 6.75 and 6.75 for irrigation levels viz. D_1, D_2, D_3 and S, respectively. The corresponding values for fertilizer doses were 6.75, 6.76 and 6.76 for F_1, F_2 and F_3, respectively. The highest pH value was recorded in the combination of D_1F_3 (6.76) and lowest value in SF_1 (6.19). At the end of irrigation cycle, the drip irrigation showed a slightly higher soil EC in comparison to surface irrigation. The effect of drip irrigation on soil OC was found to be significant. Increasing fertilizer doses tend to increase the organic carbon to the extent of 0.61, 0.63 and 0.64% under F_1, F_2 and F_3, respectively. Among the interactions, D_3F_3 recorded the highest increase in OC (0.67%) followed by D_2F_2, D_2F_3 and D_2F_3 showing almost equal value (0.65%). So, the soil pH and EC does not get affected by the drip fertigation using urea, DAP and MOP but it is for soil organic carbon.

Keywords

Drip fertigation, Alluvial soil, pH, Electrical conductivity, Soil organic carbon

Article Info

Accepted:
24 November 2018
Available Online:
10 December 2018

Introduction

With course of time and crop cultivations, soil continually receives inputs of external energy, water, gases and dissolved constituents. Losses of these same components are equally possible through radiation of heat, leaching and biological activities. These changes disturb the soil system and as well as their equilibrium that may be present. The effect of fertigation on soil chemical properties is more diffuse because fertilizers are spread in a larger area than the application of conventional fertilization (Teixeira *et al.,* 2007). Fertigation of soil with dissolved urea, DAP and MOP fertilizers is basically similar to irrigate soil with saline water except the constituents and quantities of ion species present. The above mentioned fertilizers are very commonly used by the farmers. It is reported that irrigation with raw or diluted effluents increased the pH, EC, WHC, OC and available N, P, K, Na, Ca and Mg in the soil (Kumaravelu *et al.,* 2001). Acidification in the oxidizing zone extending approximately 60 cm vertically and horizontally from the emitter when fertigated with ammonium nitrate and ammonium polyphosphate in the sandy loam soil is also observed (Parchomchuk *et al.,* 1993). Greater solubility of cations due to acidification and their possible replacement by NH^4-N at exchange sites of the clay may facilitate the displacement of Ca, Mg and K to the periphery of the acidified zone of soil. The rapid displacement of K may be of concern, particularly when NH^{4+} ion form of N is drip fertigated in coarse textured soils with marginal K levels. Banana is one of the most important leading fruit crop in India. It accounts for the production of 16.5 million tonnes annually from an area of about 5 lakh hectares. In India, drip fertigation is extensively used in the banana cultivation. Easily available and cost effective fertilizers such as urea, MOP and DAP could be effectively utilized as nutrient source in the drip fertigation instead of using high analysis costly liquid fertilizers (Singh *et al.,* 2018). The banana farmers are being constrained with technical expertise to adopt drip irrigation system otherwise the investment in the drip system may not yield a result (Singh *et al.,* 2018a). Long term use of specific type of fertilizers like acidic or basic or neutral may affect the physico chemical properties of soil which may be long term or short term. Therefore, it is imperative to study the effect of drip fertigation on the changes of soil physico chemical properties under the banana cultivation.

Materials and Methods

The field experiment was conducted during the year 2011-2012 and 2012-2013 at the Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Nadia district of West Bengal encompassing the New Alluvial Zone (9.75 m above MSL and 23^o N and 89^o E coordinate). The depth wise soil physico-chemical and chemical properties of the research field are presented in the Table 1. The groundwater having pH of 7.6 and EC of 0.62 dS/m was used for irrigation. Healthy sword suckers (2-3 leaf) weighing around 1.5-2 kg each (2.0-2.5 month old) of banana cv. Martaman (AAB group) were planted (spacing = 2m × 2m) in the square pattern. The ratoon was maintained by retaining only one sucker per plant to develop.

Estimation of irrigation water requirement

The reference crop evapotranspiration (ETo) was taken as the basis to calculate of crop water requirement (Doorenbos and Pruitt, 1977). Irrigation is provided to replenish 100, 80 and 60% of the ETo which is multiplied by suitable crop co-efficient (Kc) values according to the crop stage, their product yields crop evapotranspiration (ETc). ETo was calculated by multiplying of pan evaporation (Ep) and pan factor (Kp=0.8). The daily Ep was recorded from the USWB class-A pan installed inside the research farm. The monthly value of Kc for banana varied from 0.55 to 1.1 during first year and 1.0 to 1.2 during second year for three crop stages (Allen *et al.,* 1998). The volume of water required per plot was computed based on the equation given by Vermeiren and Jobling (1980). In case of surface irrigation, water was applied at IW/CPE 1.0 which is scheduled at 15-20 days' interval. Plots were irrigated from direct discharge of shallow tube well connected with control valve.

Fertilizer source and scheduling

Water soluble and cheaply available conventional fertilizers were used for the fertigation. Nitrogen was supplied through urea (46% N) as its primary source. Di-ammonium phosphate (46% P_2O_5 and 18% N) was used to supply phosphorus and also as secondary source of N and muriate of potash (60% K_2O) as the K source. These fertilizers are quite soluble in water, compatible to mixing together and convenient for drip fertigation (Kafkafi and Kant, 2005). The DAP fertilizer was dissolved in water one day before the irrigation with intermittent stirring and the suspensions were removed by filtering.

The drip fertigation were scheduled in splits by targeting the active growth stages of banana. The fertigation was commenced 9 weeks after planting. The nitrogen fertilizer was applied in 20 splits, phosphorus in two splits and potassium in 9 splits. Based on the nutrient requirement, the corresponding amounts of commercial fertilizers were calculated and the details of fertilizers requirement in banana is illustrated in table 2. In conventional soil application of fertilizers followed by surface irrigation at IW/CPE 1.0, the whole amount of phosphorus and 50 percent of nitrogen and potassium were broadcasted uniformly after seven weeks of planting around 30 cm to 70 cm distance from the plant base. The remaining nitrogen (50%) was applied in 3 equal splits at 5, 7 and 9 months after planting and remaining potassium (50%) was applied at 9 months after planting. The remaining fertilizers schedules for 80 percent and 60 percent of RDF were calculated accordingly.

Soil sampling and physico-chemical analysis

Soil samples were drawn from 0-30 cm depth and 30 cm away from the plant. The collected samples were air-dried and ground to pass through 2-mm sieve. Soil pH was determined from soil-water suspension in 1:2.5 ratio with the help of Systronics Microprocessor based pH meter (Model-361) as described by Jackson (1973). The electrical conductivity (EC) of soil-water suspension (1:2.5) was estimated with the help of a conductivity meter (Systronics-363) outlined by (Jackson, 1973). The electrical conductivity was measured at room temperature (25°C) after the soil particles have been settled down. Organic carbon of soil was estimated by oxidizing the soil with a mixture of 1.0 N $K_2Cr_2O_7$ and concentrated H_2SO_4 and back-titrating the excess $K_2Cr_2O_7$ with standard ferrous ammonium sulphate (0.5 N) solution using diphenylamine indicator following the wet digestion method of Walkley and Black (1934) as outlined by Jackson (1973).

To compare the effect of irrigation and fertilizer levels on the soil properties was statistically analyzed by Factorial Experiment (FRBD) given by Gomez and Gomez (1984). Four levels of irrigation (3 drips and 1 surface) were considered as Factor-1 and three levels of fertilizer (60%, 80% and 100% RDF) were considered as Factor-2, making total of 12 treatments with three replications. The statistical differences of the data generated for each year and their pooled values were tested with least significant difference (LSD) at 5% probability level using analysis of variance technique (ANOVA). The standard error of means (SEm±) and critical difference (CD) at 5% level of significance were calculated to compare the treatment means using SPSS

(Statistical Package for Social Science) software (for Windows, Version 16.0).

Results and Discussion

Soil pH

Soil pH decreased with increasing irrigation levels as apparent from the results, D_1 (6.81), D_2 (6.77), D_3 (6.75), S (6.75) but the variation among treatments were non-significant in this respect (Table 3, Fig. 1). Similarly, pH decreased slightly with increasing fertilizer levels but their difference was not significant, as revealed by the pooled data; F_1 (6.79), F_2 (6.76) and F_3 (6.76). Reduction in soil pH under increasing irrigation levels might be due to increase in organic carbon and increased rate of nitrification. But, it may be noted that organic carbon could not be the sole factor in controlling the soil pH. The slight decrease in pH with increasing fertilizer levels might be due to formation of nitrates from the urea in the soil by virtue of nitrification. Similar findings have been reported from N fertigation experiments conducted by Goha and Malkout (1992) and Parchomchuk *et al.,* (1993). Initially, urea could raise soil pH in the zone of application due to the release of NH_3, but over time, soil pH can decrease from the original pH due to the conversion (nitrification) of NH_4^+ to NO_3^- (Silva, 2000). The effect of interaction of irrigation and fertilizer levels on soil pH was found to be non-significant in the pooled value. Highest pH value (6.82) was observed in the combination at D_1F_1 and D_1F_2 and the lowest value (6.70) was recorded in D_3F_3 combination (Fig. 4). The soil pH under fertigation treatments seemed to be slightly lower than surface method of irrigation. Decrease in soil pH might have influenced the solubility of P in the soil thus increasing plant uptake. A slight increase in soil pH with increasing levels of fertilizer was noticed under surface irrigation. Under flood irrigation, the pH might be increased in surface and sub-surface soils as stated by Khanday and Ali (2012).

Electrical conductivity (EC) in soil

Results showed that irrespective of fertigation levels, there was slight increase in the soil electrical conductivity (Table 3 and Fig. 2 & 4). This might be due to the fact that some amounts of basic materials might have accumulated in the soil layer due to slow fertilizer application through drip irrigation. Similar findings have been reported by Ghazy *et al.*, (1992). The increase in EC might be due to increasing amount of K application which might have accounted for more K^+ ions in solution. The effect of drip irrigation at 0.6, 0.8 and 1.0 ETo-pan evaporation and fertilizer at 60, 80 and 100% of recommended dose of N, P and K levels on electrical conductivity was found to be significant in both the years but was not significant in the pooled data. Increased EC was observed under flood irrigation in surface and sub-surface soil, as reported earlier by Khanday and Ali (2012) in pea on a gravelly loam soil. In comparison to conventional method of irrigation it was found that under drip irrigation, soil electrical conductivity was slightly higher. The increase in electrical conductivity of soil with the increase in N and K fertigation levels was reported by Goha and Malkout (1992) and Parchomchuk *et al.,* (1993).

Soil organic carbon (OC) content

Irrespective of irrigation and fertilizer levels, there was slight increase in the oxidizable soil organic carbon (0-30 cm depth) when compared with the initial content. The effect of drip irrigation at 0.6, 0.8 and 1.0 ETo on soil organic carbon content (0.62, 0.63 and 0.65% OC respectively) was significant in both the years and also in the pooled data (Table 3 and Fig. 3 & 4). Under increased fertilizer levels, an increasing trend in OC was seen (0.61, 0.63 and 0.64% OC under F_1, F_2 and F_3 respectively). The increase in the soil organic carbon with increasing irrigation and fertilizer levels might be due to gradual accumulation of root exudates, decaying dead roots in soil under regular and optimal supply of water and nutrients under drip fertigation. It is also universally accepted fact that, under regular supply of soil moisture, say drip irrigation, more percentage of roots proliferate laterally and concentrates near the surface, thus increasing the OC in soil. The increase or decrease of values is not consistent with the levels of fertilizer application in the first and second year but clarity of gradual increase has been observed at pooled data.

The interaction between fertilizer and irrigation levels on soil organic carbon content was found to be non-significant in the first and second year as well as in pooled data of both the years. Among the interaction treatments, the treatment D_3F_3 recorded highest increase in OC (0.67%) followed by D_2F_2, D_2F_3 and D_2F_3 with almost equal value of 0.65% OC. However, the variation among treatment combinations was non-significant in both the years as well as in the pooled data. It was reported that irrigation with raw or diluted effluents increased the soil organic carbon by Kumaravelu *et al.,* (2001). In comparison, the organic carbon in soils was higher under drip fertigation, than that of conventional method. This might be due to the sudden, fluctuating and disturbing the soil equilibrium after heavy surface irrigation. Among the interaction treatments, the treatment D_3F_3 recorded highest increase in OC (0.67%) followed by D_2F_2, D_2F_3 and D_2F_3 with almost equal value of 0.65% OC. However, they are statistically on par for pooled data. Kumaravelu *et al.*, (2001) was of the opinion that irrigation with raw or diluted effluents increased the soil organic carbon. In comparison, the soils under drip fertigation, the organic carbon was higher than that of conventional method.

Table.1 Chemical properties of the experimental soil

Depth (cm)	pH (1:2.5)	EC (dS/m)	OC (mg/kg)	*N (kg/ha)	*P (kg/ha)	*K (kg/ha)
0-15	6.90	0.10	4.6	196.7	18.9	135.6
15-30	6.82	0.08	4.0	171.4	16.8	137.1
* Available						

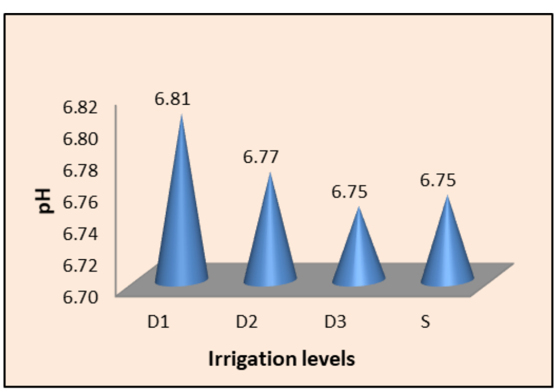
Table.2 Conversion of NPK fertilizers into actual amounts of fertilizers applied

Nutrient	Nutrient content (%)	Nutrient requirement (g/plant/ year)		
		100% RDF	80% RDF	60% RDF
N	-	200	160	120
P	-	50	40	30
K	-	250	200	150
Fertilizer used	-	Fertilizer requirement (g/plant/ year)		
Urea*	46 (N)	415	332	249
DAP	46 (P_2O_5) & 18 (N)	109	87	65
MOP	60 (K_2O)	417	333	250
* N supplied by DAP is considered				

Table.3 Effect of different levels of drip irrigation and fertilizer levels on soil pH, EC and OC under banana plantation

Treatments	pH_w (1:2.5)			EC (dS m^{-1})			Organic Carbon (%)		
Irrigation (I)	Crop I	Crop II	Pooled	Crop I	Crop II	Pooled	Crop I	Crop II	Pooled
D_1	6.82	6.79	6.81	0.33	0.35	0.34	0.61	0.63	0.62
D_2	6.77	6.76	6.77	0.34	0.36	0.35	0.63	0.64	0.63
D_3	6.75	6.75	6.75	0.35	0.37	0.36	0.65	0.66	0.65
S	6.74	6.77	6.75	0.32	0.32	0.32	0.61	0.60	0.60
SEm (±)	0.017	0.026	0.016	0.003	0.003	0.002	0.006	0.005	0.004
CD (0.05)				0.007	0.010		0.018	0.014	0.011
Fertilizer (F)									
F_1	6.78	6.79	6.79	0.32	0.34	0.33	0.61	0.61	0.61
F_2	6.76	6.76	6.76	0.33	0.35	0.34	0.63	0.64	0.63
F_3	6.76	6.75	6.76	0.35	0.36	0.35	0.63	0.64	0.64
SEm (±)	0.015	0.022	0.013	0.002	0.003	0.002	0.005	0.004	0.003
CD (0.05)				0.006	0.009		0.016	0.012	0.010
Irrigation x Fertilizer									
D_1F_1	6.83	6.82	6.82	0.32	0.34	0.33	0.60	0.61	0.61
D_1F_2	6.83	6.81	6.82	0.33	0.34	0.34	0.61	0.63	0.62
D_1F_3	6.81	6.75	6.78	0.34	0.36	0.35	0.62	0.64	0.63
D_2F_1	6.80	6.80	6.80	0.32	0.35	0.34	0.61	0.60	0.61
D_2F_2	6.78	6.77	6.77	0.34	0.36	0.35	0.64	0.65	0.65
D_2F_3	6.75	6.73	6.74	0.35	0.37	0.36	0.63	0.66	0.65
D_3F_1	6.80	6.79	6.79	0.33	0.36	0.35	0.64	0.65	0.64
D_3F_2	6.75	6.76	6.75	0.34	0.37	0.36	0.64	0.66	0.65
D_3F_3	6.70	6.70	6.70	0.36	0.38	0.37	0.67	0.67	0.67
SF_1	6.72	6.77	6.74	0.32	0.32	0.32	0.60	0.60	0.60
SF_2	6.71	6.71	6.71	0.32	0.32	0.32	0.61	0.60	0.60
SF_3	6.80	6.82	6.81	0.33	0.33	0.33	0.62	0.59	0.60
SEm (±)	0.030	0.045	0.027	0.004	0.006	0.004	0.011	0.008	0.007

Fig.1 Influence of irrigation and fertilizer levels on soil pH (pooled data for 2 years)



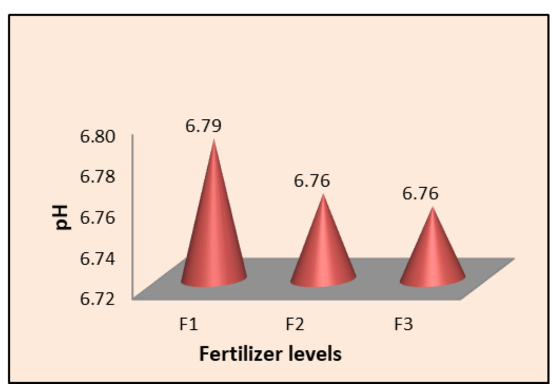
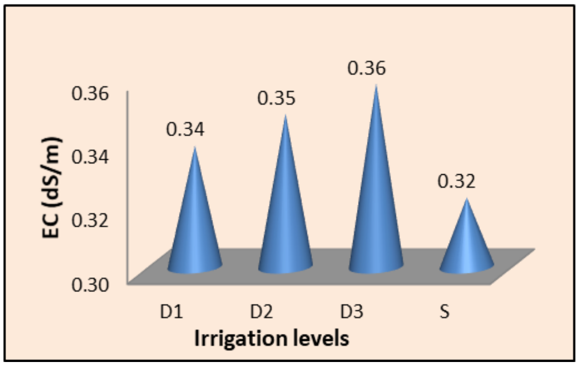


Fig.2 Influence of irrigation and fertilizer levels on soil pH (pooled data for 2 years)



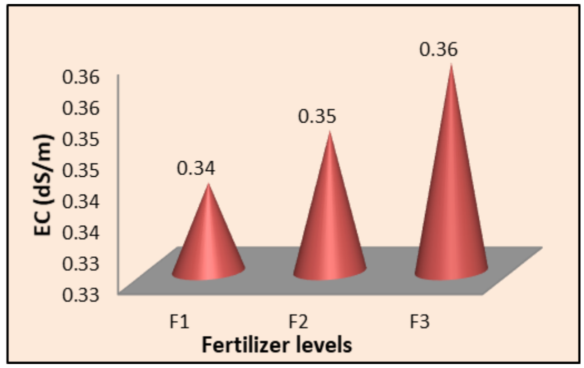
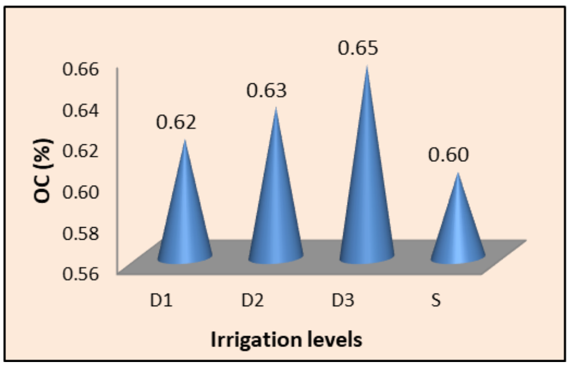


Fig.3 Influence of irrigation and fertilizer levels on soil organic carbon (pooled data for 2 years)



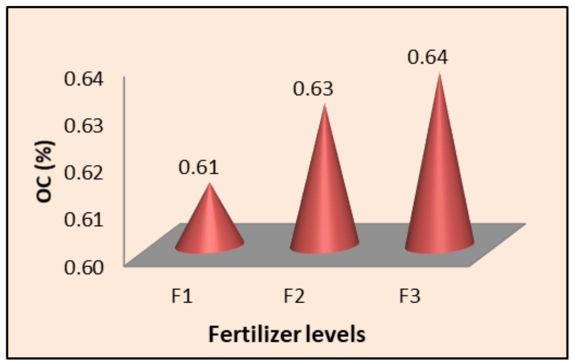
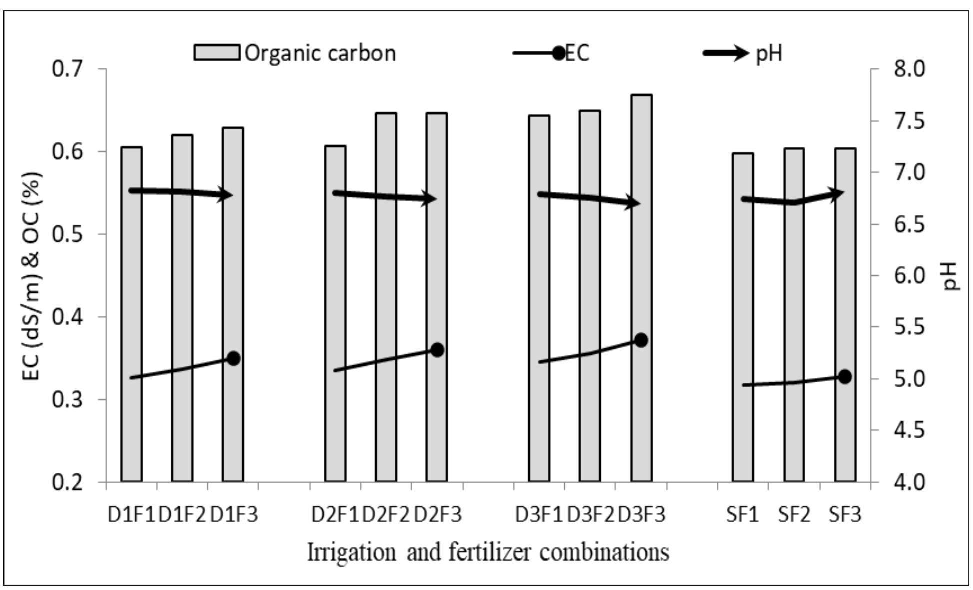


Fig.4 Influence of various irrigation and fertilizer levels on soil pH, EC and organic carbon after the harvest (pooled data for two years)



This could be attributed to the sudden, fluctuating and disturbing the soil equilibrium after heavy surface irrigation. Under low soil organic matter stock, N supply through mineralization is not sufficient to maintain the N balance for banana and but a large part of the N from banana crop residues was directly transferred to soil organic N pool (Dorel *et al.*, 2008). Soils under drip fertigation received water and dissolved constituents continuously unlike the surface and conventional method of fertilization. These changes perturb the soil system and might have disturbed the equilibrium (Schwab, 2005). Drip-fertigation as well as surface method of irrigation largely alters the physical, physico-chemical and biological properties of soil. Khanday and Ali (2012) observed that, the soil physico-chemical properties responded significantly to the interactive effect of fertilizer levels and the irrigation systems. Teixeira *et al.*, (2007) opined that effect of fertigation on soil chemical properties is more diffuse because the spread of fertilizers uniformly than the conventional soil fertilization. With minimal disturbance of the soil and with the supply of irrigation water through drip, soil never attain the anaerobic condition which may deter the growth and function soil microorganisms might have prospered in building up the soil organic carbon.

In conclusion, considering, the minimal change in the studied soil properties during the fertigation it may be concluded that, the soil pH and EC does not get affected by the drip fertigation using urea, DAP and MOP. The effect of other kind of fertilizers including liquid fertilizers may be tested under long term condition so that better understanding is established.

Acknowledgements

The authors are thankful to Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal for providing the facility and technical support to carry out this field experiment.

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How to cite this article:

Basanta Singh, T., S.K. Patra, L. Joymati Chanu, Laishram Kanta Singh, T.H. Narjit Singh, Romio Singh, W. Merinda and Bibek Laishram. 2018. Influence of Drip Fertigation on Physico-Chemical Properties of an Alluvial Soil of West Bengal, India. *Int.J.Curr.Microbiol.App.Sci.* 7(12): 3535-3543. doi: https://doi.org/10.20546/ijcmas.2018.712.400