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Leaching losses of primary nutrients, organophosphate based and carbamate based insecticides in various soil types of Konkan region under rice crop

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Abstract
The research was conducted on the "LEACHING LOSSES OF PRIMARY NUTRIENTS, Organophosphate Based And Carbamate Based Insecticides IN VARIOUS SOIL TYPES OF KONKAN REGION UNDER RICE CROP" at Dr.B.S.K.K.V., Dapoli, Dist. Ratnagiri. The experiments was conducted with three soil types dominant in Konkan region *viz.,* Lateritic, Medium black and Coastal saline soil which included the RDF along with two sources of pesticides (Carbofuron and Phorate) with rice (*var.* Sahyandri-4). Another experiment replicated thrice to study the movement behavior of pesticides at the different depths of soil profile at 0-30, 30-60 and 60-90 cms was determined. The leaching loss of pesticides through the column was also quantified. Among the primary nutrients (N, P and K) the leaching losses of phosphorous in all soil types under study was found to be negligible as compared to nitrogen and potassium indicating immobility. The overall data regarding to the leaching losses of the N, P and pesticides from soil under rice crop as influences by various treatments showed trend viz. Lateritic soil > Medium black soil > Coastal saline soil and study indicated that these parameters were significantly affected due to pesticides treatments. However in case of potassium leaching losses from soil under rice crop as influences by various treatments showed trend Coastal saline soil > Lateritic soil > Medium black soil and study indicated that these parameters were significantly affected due to pesticides treatments. Among the two pesticides when compared, the leaching losses were higher in Carbofuron treatments (1.84 to 7.59 percent) than Phorate (0.63 to 5.91 percent) irrespective of soil type. The results of the leaching column experiments indicated that, the maximum pesticides leaching loss through percolates occurred in Lateritic soil and minimum in Coastal saline soil. Among the two pesticides studied, the losses of Carbofuron were found more than Phorate due to its higher solubility in water. The pesticides residue in surface (0-30cm) soil of leaching column was found maximum upto 30thday sampling thereafter it gradually decreased due to degradation and leaching losses. The vertical downward movement of pesticides across the layers was seen maximum in Lateritic soil and least in the Coastal saline soil. Carbofuran moved faster through the layer than Phorate.

Keywords: soil profile, cation exchange capacity, lateritic soil, medium soil and coastal saline soil.

1. Introduction
Agriculture is the base of Indian economic development and is among the largest agricultural societies in the world. The agricultural sector contributes nearly higher percent of the gross domestic production and it provides livelihood to approximate peoples. Agricultural production has recorded remarkable growth over the past few decades. Though the high yielding varieties and hybrids have contributed significantly towards improving production, these varieties and hybrids are more demanding in terms of water requirement, insecticides and fertilizers. NPK are major nutrients required by all the crops for their growth. The fertilizers are required for the nutrient support to the plant growth. The transformation of added fertilizers greatly depends on physical and chemical environment of the soil. In India, mainly carbamates and organo-phosphate pesticides are used. Besides preventing the losses due to insects, insecticides also affect the populations and activity of beneficial microorganisms in soil. Some insecticides may favorably affect the growth and activities of microorganisms in soil (Das *et al*., 2003) [11] while others have adverse effects on the growth of soil micro flora.
Soil plays an important role in water and chemical movement through it. The soil type has a great important influence on nutrient and pesticides leaching losses as the movement of these

nutrients and pesticides in water is affected by the soil characteristics which define their retention. The factors known to influence the fate and behaviour of insecticides in soil systems. Moreover factors such as composition of soil, physical nature of chemical fertilizers and insecticides, soil reaction, nature of the saturating cations on the soil exchange sites and nature of the formulation directly influence the mobility of these compounds/chemicals in the soil system. The fertility status of soil is one of the most important factor governing the yield and quality of rice crop. The soil type has a great important influence on nutrient leaching losses as the movement of these nutrients in water is affected by the soil characteristics which define their retention. The factors known to influence the fate and behavior of fertilizers in soil systems. The total amount of rainfall or irrigation water received, the intensity (water flux) and frequency of received water, all appear to effect movement of these chemicals in soils. Fertilizers can move from their initial distribution by a number of processes. Transport of these may be the result of processes such as, the formation of soluble complexes with soil solution components such as dissolved organic matter and metals or the incomplete interaction of these compounds with the solid state organic or inorganic matter in the soil.

Leaching loss of pesticides and nutrients through soil under crop is the major mean of transport of nutrients. Leaching means vertical downward movement of water due to gravitational force. With percolating water, nutrients and pesticides dissolved in water and water move from the point of application to a deeper horizon of the soil profile. The extent of leaching of primary nutrients and pesticides is determined by the solubility, adsorptive properties and their respective application rate as well as by the water movement in soil due to the different physico-chemical characteristics of the various types of soil. Through this process the nutrients and pesticides can reach the water table and then move with the water table. If nutrients and pesticides are lost in the leaching water, part of the cost of the nutrient input is being lost, as these nutrients and pesticides are no longer available for the growth of the crop. Thus, there is a one economic aspect to this concern, primarily because nutrients and pesticides input in the form of chemical fertilizers and pesticides are a major cost of production for crops and particularly so for crop production. The loss of major nutrients and pesticides from soil with water during periods of crop growth not only reduces the nutrient use efficiencies but also has the potential for environmental degradation.

An experiment was conducted to investigate the effect of Phorate (O,O-diethyl-S-ethylthiomethyl dithiophosphate) and Carbofuran (2,3-dihydro-2,2-dimethyl benzofuran-7-yl-N-methylcarbamate) at their recommended field application rates, on the nutrient availability as well as the persistence of the insecticides in the rhizosphere soils of rice. Since Phorate (an organophosphate) and Carbofuran (a carbamate), the two systemic granular insecticides, are frequently used to combat the insects in rice cultivation, it becomes imperative to evaluate their effects on nutrient availability in rice fields.

Fertilizers and pesticides are costly inputs and need to be managed efficiently for higher nutrient recovery returns. The average use of fertilizers in Konkan region was 60.6 kg (N + P_2O_5 + K_2O) ha^{-1} during 2001 - 2002 (Anonymous 2002). The fertilizers contribute 50 to 60 per cent in crop yield enhancement.

Combined application of fertilizers and pesticides unfailingly at their recommended dose sustained productivity. Therefore, the present investigation *viz.*, "LEACHING LOSSES OF Primary Nutrients, organophosphate based and carbamate based insecticides In Various Soil Types of Konkan Region under Rice Crop" was undertaken.

The first zone includes the laterite and lateritic soils which occupy whole Ratnagiri district and southern portion of Raigad district. The soils are developed from basalt by process of laterization. The soils are acidic in reaction due to leaching of bases. In general, poor in fertility and have high P-fixing capacity.

The second zone comprises whole of Thane and remaining northern part of Raigad district. The soils of these zones are Medium black and neutral to slightly alkaline in reaction. They contain free calcium carbonate and are poor in phosphorous content, medium to high in nitrogen and potassium contents.

The soils along the west coast of the Konkan (Panvel) is known as Coastal saline soil and it covers an area of about 65,465 ha (Report of the *Khar* Land Development committee, 1982). The alluvium is mostly derived from trap and the soils are impregnated with salts to a varying degree according to their location in respect to sea. The soils in immediate vicinity of sea are highly saline inspite of rainfall. The texture of Coastal saline soils ranges from clay loam to clay.

2. **Material and Methods**:

The research was conducted on the "Leaching Losses of Primary Nutrients, organophosphate based and carbamate based insecticides In Various Soil Types of Konkan Region under Rice Crop" during *Kharif*, 2012 at the College of Agriculture, Dapoli, Dist. Ratnagiri. In order to represent these three distinct zones of Konkan, three representative soil profiles samples, one each from Lateritic, Medium black and Coastal saline soil were collected from different tahsils of Konkan namely Dapoli, Karjat and Panvel. All the locations are the Agricultural Research centers of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. At each location one rice growing soil profile was selected. From each of the mentioned locations, one profile sample (0-30cm, 30-60cm and 60-90cm) collected by following standard procedure of soil sample collection. With surface soil samples, one set of experiment (experiment- I) was subjected to study leaching losses of NPK and pesticides from rice growing pots while the other set of experiment (experiment- II) with soil samples at various depth, study was subjected to leaching losses of pesticides as well as their movement and distribution using soil column were carried out without rice. Pot culture experiment was conducted in plastic pots of 10 kg capacity having 30 cm diameter and 45 cm height. These pots were placed at the bottom with a hole to collect leachates. Small quantities of pebbles were put at the bottom of the pots and ten kg of soil was filled in each pot. Treatment wise fertilizers were added and mixed thoroughly. The recommended dose of NPK (150:50:50) treatments were applied through urea, SSP and MOP. Nitrogen @ 150 kg ha^{-1} was applied in three splits *viz.*, first dose of 40 per cent N at the time of transplanting, second dose of 40 percent 30 days after transplanting and third dose of 20 percent 60 days of transplanting. Phosphorus @ 50 kg ha^{-1} and potassium @ 50 kg ha^{-1} were applied in a single dose at the time of transplanting as per the treatments. The plant nutrients were applied through fertilizer *viz*., urea, single super phosphate and muriate of potash for N, P and K respectively.Pesticides PI (Carbofuron3G) @ recommended doze of 16.5 kg ha^{-1} and pesticide PII (Phorate10G) @ recommended doze of 10.0kg ha^{-1} was applied as basal doze at the time of transplanting to each pot calculated on the basis of 10 kg soil per pot. The seedlings of rice crop (variety Sahyandri-4) were collected from the farm of Dept of Botany, College of Agriculture, Dapoli. 21 days old rice seedlings were used for transplanting. The soil was kept submerged (under 2.5 cm water) throughout the crop growth period. The hybrid rice variety Sahyadri-4, released by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli in was taken as a test crop during *Kharif* 2012 and 2013. Sahyadri-4 is mid-late (115 to 120 days) in duration, having long slender grain with 90 to 120 cm plant height, non-lodging, non-shedding and has yield potential of about 6.5 to 7.0 tons per hectare. There were nine treatment combinations in three replication. Lateritic soil +RDF, Lateritic soil +RDF + $P_{1,}$ Lateritic soil + RDF + P_2, Medium Black soil + RDF, Medium Black soil + RDF + $P_{1,}$ Medium Black soil + RDF + $P_{2,}$ Coastal saline soil +RDF, Coastal saline soil +RDF + $P_{1,}$ Coastal saline soil +RDF + $P_{2.}$ Lecheate samples were collected at 7 days inerval i.e 0-30 DAT, 30-60 DAT, 60-90 DAT ays interval which were preserved and pooled for analyzed of the pesticides content. The experiment-I were laid out separately in CRD design with nine treatments and replicated three times for each set of experiments.

The Experiment-II was conducted by using the profile soils packed in the column according to the depth of 0-30cm, 30-60cm and 60-90cms. The leaching losses of pesticides as well as their movement and distribution in profile of different soil types using soil column were carried out. Experiment-II was conducted in column in absence of any crop so as to study the movement behavoiur of the pesticides without crop. With the purpose to reduce the effect of crop in movement, distribution as well as leaching losses of pesticides, the leaching column experiment was set up without rice crop. Leaching column experiment was conducted in Plexiglass column of 1 kg capacity having 90 cm height and 4.5 cm diameter. Plexiglass column was filled up with soil layers at different depth (0-30 cm, 30-60 cm and 60-90 cm) as per treatment from various soil profiles. Filter paper pieces will be placed on the surface, inside the column to provide uniform distribution of water. Column were shaken and tapped during filling and saturated with water to aid in soil compaction. Soil filled columns were kept in the upright position during saturation with water from the top of the column and during leaching of the pesticide. A time controller syringe pump was used to apply an intermittent pulse of water to the top of the column. Soil column were kept for 30, 60 and 90 day for collecting the percolates 0-30, 30-60 and 60-90 DAA used for study as per treatment. Applications of insecticides at the top of column as per the treatment were done. Application of water was done through time controller syringe pump. Periodical percolates were collected in glass flask for analysis. Collected percolates preserved with preservatives in umber coloured glass bottle for analysis. The experiment were laid out separately in FCRD design with nine treatments and replicated three times for each set of experiments. PI: Carbamates insecticide: Cabofuron3G @ 7366.0 ug column^{-1}), PII: Organophosphates insecticide: Phorate10G @ 4464.0 ug column^{-1}). In order to know the pattern of leaching losses of pesticides from leaching column treatment wise leachate were collected at seven days interval and leachate were pooled for analysis of pesticides. Soil column were kept 30, 60 and 90DAA as per treatments for collecting the percolates were used for study. The leachate were preserved with preservatives in the brown colored bottle. The lecheate were then analyzed to know the content of pesticides. soil sampling done from column by Cutting of column at depth 30, 60, 90cm after 30, 60 and 90 DAA to observe the distrubution and movment of pesticides at various depth of soil profile.

Ammonical Nitrogen in lecheate from (experiment-I) was determined by distillation using MgO as prescribed by (Tanadon, 1993) [33] Nitrate Nitrogen in lecheate (experiment-I) determined by distillation using Devarda,s alloy as prescribed by (Tanadon, 1993) [33]. Potassium in lecheate (experiment-I) determined by using Flame photometer as prescribed by (Tandon, 1993) [33] Phosphorousin lecheate (experiment-I) determined by using mixture of Ammonium molybdate and potassium antimony tartarate which get reduced by ascorbic acid and form Molybdenum blue colour was developed as prescribed by (Tandon, 1993) [33]. Carbofuron and Phorate residue in water: It determined by using AOAC method given by Sharma (2005). The data were statistically analyzed by using the standard procedure given by Panse and Sukhatme (1967) [19].

3. Results and Discussion

Table 1: Properties of different soil type of konkan region

	Lateritic soil			Medium black			Coastal saline		
	0-30	30-60	60-90	0-30	30-60	60-90	0-30	30-60	60-90
pH	5.80	6.10	6.40	7.0	7.2	6.9	7.3	8.4	8.4
Ec	0.08	0.09	0.06	0.14	0.11	0.13	3.8	4.2	3.0
Av.Nitrogen kg ha^{-1}	298.8	311.4	273.5	258.3	259.4	247.8	312.4	302.3	308.4
Av P_2O_5 kg ha^{-1}	9.1	9.0	9.8	18.4	17.4	15.6	23.5	20.5	16.5
Av.K_2O kg ha^{-1}	229.8	249.3	232.6	270.0	282.5	260.4	972.0	972.0	982.6
CEC Cmole(P^+)kg^{-1}	28.40	31.69	30.45	40.56	34.40	37.59	46.6	49.4	41.4
Infilteration rate	2.1			1.4			0.9		
sand	59.52	37.00	32.52	39.88	38.96	42.96	33.0	40.96	44.96
silt	14.72	28.00	36.00	24.36	22.0	24.00	20.48	28.00	30.00
clay	25.76	35.00	31.48	35.76	39.04	33.04	46.48	31.04	25.04
texture	Sandy clay loam	Clay loam	Clay loam	Clay loam	Clay loam	Clay loam	Clay	Clay loam	Clay loam

3.1 Leaching losses of Nitrogen

The leaching losses of the nitrogen in the leachates were analyzed for both the form of nitrogen ammonical-N, and nitrate-N from soil. (Table 2)

The leaching losses of ammonical-N was found to be significantly superior in T_3 (Lateritic soil + RDF + Phorate) treatment at each sampling period.The maximum leaching loss of ammonical-N and nitrate-N occurred at 30 DAT and afterwards it showed a gradualy declining trend in subsequent observations and it was recorded minimum on 90 DAT. The ammonical-N content in the leachate was highest at 30 DAT due to highest disintegration of aggregates, unclogged soil pores, limited utilization of applied N by the establishing rice seedlings, then markedly declined from 60 and 90 DAT due to higher root development and foraging capacity of plant. (Suresh *et al.,* 1994) [34]. Application of pesticides (Carbofuron and Phorate) increased the leaching losses of ammonical-Nand nitrate-N in the soil at each sampling period of rice as compared to pesticide untreated soil i.e. RDF alone irrespective of soil type.

Table 2: Leaching losses of nitrogen at different growth stages of rice crop as affected by various treatments

Treatment	Nitrogen (mg pot^{-1})									Grand Total N loss	% N loss
	30 DAT			60 DAT			90DAT				
	NH_4^+-N	NO^-_3-N	Total N loss	NH_4^+-N	NO^-_3-N	Total N loss	NH_4^+-N	NO^-_3-N	Total N loss		
T_1	38.48	19.52	58.00	30.96	15.12	46.08	27.79	12.17	39.95	144.03	21.67
T_2	38.99	19.91	58.89	31.64	15.28	46.91	29.10	12.42	41.52	147.33	22.16
T_3	39.22	20.14	59.35	31.73	15.37	47.10	29.31	12.53	41.84	148.29	22.31
T_4	24.19	14.49	38.69	20.77	9.12	29.90	18.21	7.10	25.30	93.89	14.13
T_5	24.93	14.93	39.86	21.15	9.35	30.51	18.25	7.27	25.52	95.88	14.43
T_6	25.16	14.98	40.14	21.36	9.47	30.83	18.43	7.42	25.85	96.82	14.57
T_7	9.49	7.95	17.44	9.00	5.71	14.71	5.39	3.33	8.72	40.88	6.15
T_8	9.72	8.20	17.93	9.07	5.94	15.01	5.58	3.78	9.35	42.29	6.36
T_9	9.84	8.23	18.06	9.16	6.04	15.20	5.67	3.96	9.63	42.89	6.45
SEm$\pm$	1.67	1.49		1.34	1.58		1.32	1.13			
CD@ 1%	4.82	4.30		3.86	4.55		3.81	3.25			

This may be due to higher exchangeable ammonical-N and Nitrate-N content in pesticide treated soil than pesticide untreated soil. Das and Mukherjee (2000a, b), Singh and Prasad (1991) [31], Das and Mukherjee (1998b) [10] reported that mineralization of N increased due to the application of insecticides in soil under rice crop. Das *et al*., (2003) [11] reported that application of insecticides (Phorate, Carbofuron) at their recommended dose stimulated the population of bacteria, actinomycetes and fungi in the rice rhizosphere soils whereas Singh and Prasad (1991) [31], reported that an increase in the amount of exchangeable NH_4-N and Nitrate-N in pesticides treated soil attributed due to the stimulation of the growth and activities of ammonifying and nitrifying bacteria which were mainly responsible for mineralization of organic N and convert it into exchangeable ammonical-N and nitrate-N form.

Among the pesticides, the treatments receiving Phorate recorded the high leaching losses of ammonical-N and nitrate-N in soil at all the sampling interval of rice which were significantly superior over Carbofuron and RDF treated treatment irrespective of soil type. Das and Mukherjee (1994) [8], Das and Mukherjee (1998b) [10] and Das *et al*., (2003) [11] also showed that the increased in exchangeable NH_4-N and Nitrate-N availability was more in case of Phorate as compared to Carbofuron due to stimulation was more pronounced with Phorate as compared to Carbofuron resulting in increased population sizes and activities of ammonifying and nitrifying bacteria which in turn influences the transformations of plant nutrient elements in soil and increasing its availability of exchangeable NH_4-N and Nitrate-N.

The total (0-90 DAT) leaching loss of ammonical-N was observed maximum (13.37 to 15.08 percent of applied quantity) from the Lateritic soil followed by Medium black soil (9.5 to 11.37 percent) and was minimum in Coastal saline soil (3.59 to 4.21 percent). The total loss of nitrate-N over 90 days was observed maximum (6.63 to 7.23 percent of applied quantity) the Lateritic soil followed by Medium black soil (3.85 to 4.79 percent) and was minimum in Coastal saline soil (2.50 to 2.74 percent).

The higher Ammonical-N percent leaching loss content in the leachate as compared to nitrate-N was because in wetland soil, very little amount of NH_4-N is oxidized to NO_3-N due to the reduced conditions and the mineralization of the fertilizer N proceeds up to the formation of NH_4-N only (Suresh *et al*., 1994) [34]. Santra *et al*., (1994) [25] reported that leaching loss of nitrate-N was highest during initial crop period days which declined as the period of submergence increases. This slow decline may be due to decreasing in concentration of nitrate-N in the soil solution resulting from the denitrification mechanism and also due to increased anaerobic condition with the progress of time minimizing the possibility of nitrification of NH_4-N in soil. The nitrification reaction stops at ammonical-N formation step in lowland paddy soil. Results also indicate that the relative magnitude of loss of nitrogen as NH_4-N is always higher than that of nitrate-N. Singh and Aulakh (2001) [30] observed that as water logging increases, O_2 transport decreases & ammonification reaction increases because of the anaerobic nature. Santra *et al.* 1994 [25] reported that less nitrate-N losses may be due to decreased in concentration of NO_3-N in the soil solution resulting from the denitrification mechanism and also due the anaerobic condition with the progress of time minimizing the possibility of nitrification of NH_4-N in soil.

Lateritic soil is being light textured and low CEC and higher infiltration rate while favoured easy downward movement of of leachate as compared to other two soil types (Medium black and Coastal saline soil. High cation exchange capacity in Vertisol possibly caused greater retention as well as lower hydrolysis of urea (Purakayastha and Katyal 1998) [23]. Within the different soils under study the total quantity of ammonical-N and nitrate-N leaching looses was found be more in Laterltic (Dapoli) soil. Velu and Ramanathan (1998) reported that leaching loss of ammonical-N and nitrate-N are more in soils dominated by Kaolinite type 1:1 type mineral. The leaching losses of ammonical-N were recorded less in soils dominated by 2:1 type smectite clay minerals. This clay has a higher retention capacity as compared to Kaolinite type 1:1 type minerals.

The lowest value of leaching loss of ammonical-N in percolates of Coastal saline soil can be attributed to its saline nature. Bandhopadyay and Bandhopadyay (1983) [3] observed that the rate of mineralization of nitrogen was slowed down by increase in soil salinity. The rate of conversion of one form of N to other form is quite slow in salt affected saline soil than non saline soil.

3.2 Leaching losses of phosphorous and potassium

Table 3: Leaching losses of phosphorous and potassium at different growth stages of rice crop as affected by various treatments.

Treatment	P (µg pot^{-1})				% P loss	K (mg pot^{-1})				% K loss
	30 DAT	60 DAT	90 DAT	Total loss		30 DAT	60 DAT	90 DAT	Total loss	
T_1	4064.0	1936.0	1056.0	7056.0	3.16	29.16	13.81	8.90	51.88	23.24
T_2	4074.7	2000.0	1120.0	7194.7	3.22	29.40	14.07	9.16	52.63	23.58
T_3	4144.0	2032.0	1136.0	7312.0	3.28	29.70	14.31	9.52	53.53	23.98
T_4	2928.0	1509.3	816.0	5253.3	2.35	18.44	13.35	7.90	39.70	17.79
T_5	2960.0	1552.0	848.0	5360.0	2.40	18.68	13.77	8.32	40.78	18.27
T_6	3008.0	1584.0	912.0	5504.0	2.47	19.04	14.01	8.50	41.56	18.62
T_7	1664.0	1312.0	736.0	3712.0	1.66	65.27	47.90	25.15	138.32	61.97
T_8	1712.0	1344.0	768.0	3824.0	1.71	65.75	48.08	25.57	139.40	62.46
T_9	1744.0	1360.0	784.0	3888.0	1.74	66.11	48.38	25.75	140.24	62.83
SEm±	0.67	0.26	0.24			1.02	1.15	1.29		
CD@ 1%	1.95	0.74	0.71			2.93	3.30	3.72		

The leaching losses of phosphorous was found to be significantly superior in T_3 (Lateritic soil + RDF + Phorate) treatment at each sampling period.In all soil types under study, the maximum leaching losses of phosphorous was observed at 30 DAT and it declined steadily during the crop growth upto 90 DAT. (Zhang *et al.* 2007) [38] Sharma and Mishra (1988) [26] also reported that the maximum leaching loss of phosphorous occurred at 30 DAT and afterwards it showed a declining trend. The higher leaching losses of phosphorous at 30 DAT sampling may be because of application of full dose of phosphorous as a basal dose to rice growing pots. Simard *et al.* (2000) [29] reported that P leaching losses was found higher during the initial period and decreased thereafter. The minimum leaching losses of applied phosphorous at 90 DAT rice growing pot may be because of it is fixed by soil colloids or organic matter and other ions (Ca, Fe, Al and Mg) present in the soil.

Application of pesticides (Carbofuron and Phorate) increased the leaching losses of phosphorous content in the soil as compared to pesticide untreated soil. This may be due to higher availability of phosphorous in pesticide treated soil than pesticide untreated soil. (Das *et al.*, 2003) [11].

Among the pesticides, the treatments receiving Phorate recorded the slightly higher leaching losses of phosphorous in soil over Carbofuron. This might be due to the Phorate was more effective than compared to Carbofuron in contributing to the higher value of available phosphorous content in soil.

The maximum percent in the leaching loss over 90 days was observed maximum (2.58 to 3.28 percent of applied quantity) in Lateritic soil followed by Medium black soil (2.02 to 2.47 percent) while it was minimum (1.18 to 1.74 percent) in Coastal saline soil.

The highest value of phosphorous in lechates of Lateritic soil are due to phosphorus adsorption is higher (CEC) and vermiculite content. The higher leaching losses of phosphorous in Lateritic soil may also be due to the soil being a light textured, low CEC and higher infiltration rate favoured easy downward movement and leaching of applied phosphorous as compared to Medium black soil having high CEC and low infiltration rate.

The total leaching loss of phosphorus over 90 day was found lowest in Coastal saline soil as compared to Lateritic and Medium black in the present study. The rate of leaching loss of phosphorous is minimum in Coastal saline soil because of saline nature of the soil and higher salts content than non saline soil.

3.2.1 Leaching losses of potassium at different growth stages of rice crop as affected by various treatments

Leaching losses of potassium steadily decreased from 0 to 90 days of the growth period of the crop. Similar Observations of declined potassium over the growth period of the crop were reported by Suresh *et al.*, (1994) [34]. It can be also observed that the leaching loss of potassium in pesticide treated soil to slightly higher than the untreated soil. This may be due to application of full dose of potassium as a basal dose. Karande (1985) [13] also reported similar results. The higher level of losses in pesticide treated soils may be due to higher availability of potassium in pesticide treated soil than pesticide untreated soil. The higher value of available potassium in pesticides treated soil was also reported by (Bagal 2009) [1].

The leaching losses of potassium was found to be significantly superior in T_9 (Coastal saline soil + RDF + Phorate) treatment at each sampling in experiment and was at par with T_8 and T_7 treatment. The leaching loss of potassium when compared to the different soil types reveals that maximum loss was observed in Coastal saline soils (60.34 to 62.83 percent of applied quantity) followed by Lateritic soil (23.24 to 25.33 percent) and was minimum in Medium black soil (16.79 to 18.62 percent). The higher leaching loss of potassium in Coastal saline soils may be due to higher native potassium content in the soil. The highest value of potassium in leachates of Coastal saline soil was also reported by Laxminarayana *et al.*, (1990) [15]. They further reported that the leaching losses of K from coastal soil column with treatment of potassium fertilizers through KCl and K_2SO_4 within 80 days were very high (35.5 and 53.3 percent of applied K) from KCl and K_2SO_4 respectively. The rate of leaching loss of K from coastal saline soil is several times higher than Lateritic soil and Medium black soil because of saline nature and rich in water soluble-K content than non saline soil. Being saline nature it contains potassium as major accumulated salts added through sea water (Joshi 1985) [12]. Similar observations were also recorded by (Mali 1989) [17]. Similar results were also reported by Sharply *et al.*, (1990) [27] and Sreenivas *et al.*, (2008) [32]. The leaching loss of potassium were recorded less in Medium black as compared to Lateritic soil because the Medium black soil dominated by 2:1 type smectite clay minerals and red Lateritic soil dominated by Kaolinite type 1:1 type mineral as reported by Bajwa *et al.*, (1993) [2] and Sharply *et al.*, (1990) [27].

3.3 Leaching losses of pesticides at different growth stages of rice crop as affected by various treatments.

The data regarding the to the leaching losses of the pesticides from soil under rice crop at different growth stages at weekly interval upto 49 days were influenced by various treatments. However the analysed data of pesticide residues is presented in Table 4 by combining the leachates of 0-28 and 29-42.

Table 4: Leaching losses of pesticides at different growth stages of rice crop as affected by various treatments

Pesticides leaching losses	µg pot^{-1}							
	Lateritic		Medium black		Coastal saline		SEm±	C.D.
	PI	PII	PI	PII	PI	PII		
0-28DAT	3728.8	2914.03	2034	925.7	904.0	313.8	22.00	67.80
29-42 DAT	1866.3	1444.1	1010.6	460.6	453.1	154.7	6.12	18.88
Total loss	5595.1	4358.1	3044.6	1386.3	1357.1	468.6	22.51	69.36
% Loss	7.595	5.91	4.13	1.88	1.84	0.63		

PI: Carbofuron, PII: Phorate

The data indicated that, among the various soil types, the trend of per pot cumulative total pesticides leaching loss was found viz. Lateritic (5.91 to 7.59 percent) > Medium black (1.88 to 4.13 percent) > Coastal saline soil (0.63 to 1.84 percent). The leaching losses of pesticides were maximum from 0-28 days irrespective of soil types. The trend in leaching loss of pesticides showed a decrease because of application of full dose of pesticides as a basal dose. The highest leaching losses of pesticides in Lateritic soil attributed for its low CEC and higher infiltreation rate. Similar results were also reported by Parama *et al*., (1991) [21]. Choudhary *et al.*, (2006) [7] and Sundaram (1994) [33] reported that the leaching losses pesticides amount was found higher from kaolintic clay minerals which are dominant in Lateritic soil as compared to smectitic clay which is dominant in Medium black and Coastal saline soil. The Coastal saline soil exihibited minimum leaching losses of pesticide because of its compact nature, high CEC, low infiltration rate and saline nature of soil.

Among the two pesticides when compared the leaching losses was higher in Carbofuron (1.84 to 7.59 percent) than Phorate (0.63 to 5.91 percent) because Carbofuron has higher solubility (320 mg liter^{-1}) in water than compared to Phorate (22 mg liter^{-1}). Sundaram (1994) [33] and Paraíba *et al.*, (2007) [20] reported that extent of leaching losses of pesticide is determined by the solubility, adsorptive properties and rate of degradation of the pesticide, as well as by the water movement in soil, and the physical and chemical characteristics of the soil. Nicosia *et al*., (1990) [18] reported the similar results.

3.4 Effect of different treatments on yield of rice (Grain and straw)

The data regarding to the grain, straw yield and total (grain+straw) biomass yield of rice (Sahyadri-4) as influenced by various treatments in experiment is presented in Table 5.

Table 5: Effect of different treatments on grain yield and straw yield of rice

Treatment	2012 (g pot^{-1})		
	Grain wt.	Straw wt.	Total
T_1	13.6	15.3	28.9
T_2	15.1	17.9	33.0
T_3	15.4	18.1	33.5
T_4	18.8	21.1	39.9
T_5	19.5	24.6	44.1
T_6	19.8	25.0	44.9
T_7	9.78	12.5	22.2
T_8	10.1	13.0	23.1
T_9	10.5	13.1	23.6
SEm±	0.70	0.71	
CD@ 1%	1.47	1.51	

The highest grain and straw yield was recorded in Medium black followed by Lateritic soil and was lowest in Coastal saline soil. The highest grain and straw yield was observed in Medium black soil over Lateritic soil type might be due to high fertility of this soil along with dominance of Smectitic clay minerals. Similar results were quoted by Patil (2001) [22].

Application of pesticides (Carbofuron and Phorate) increased the grain and straw yield of rice in the soil as compared to pesticide untreated soil. Das and Mukherjee (1998b) [10] reported that the yields of the crop were increased due to application of pesticides. This may be due to higher availability of nutrients content in pesticide treated soil than pesticide untreated soil. Das *et al*., (2003) [11] reported that application of insecticides (Phorate, Carbofuron) at their recommended dose stimulated yield and yield contributing character of rice. The treatments receiving Phorate recorded the highest the grain yield of rice which were higher over Carbofuron in all soil type. Similar results were quoted by Das *et al*., (2003) [11]. They further reported that the insecticide stimulation of both grain and straw yield was in order BHC> Phorate> Carbofuron. (Das *et al*., 1998) [9]. The grain and straw yield of rice was recorded lowest in Coastal soil experiment might be due to the saline nature. Salinity of Coastal saline soil is main cause for low yield of rice. Soil salinity is main cause for minimizing the yield of rice even after presence of essential available nutrients. The increased osmotic pressure and high salt content of Coastal saline soil leads to make the rice crop deficient even after higher available essential nutrients content in soil. Mahmood *et al*. (1999) [16] conducted pot culture experiment and concluded that, the grain yield and yield contributing characteristics of rice varieties was reduced by 30 per cent with saline soil over the normal soils.

3.5 Effect of soil types on pesticides leaching losses and their movement in soil profile at different depth. (Experiment-II)

Leaching losses of pesticides from different soil matrices (column) as affected by various treatments.

The data regarding the leaching losses of the pesticides from soil matrices at 30, 60 and 90 DAA (Day after application) as influenced by various treatments is given in Table 6

The leaching losses of the pesticides in the percolates from soil column at various DAA (30, 60 and 90 DAA (Day after application) to soil were analyzed for both the pesticides viz., PI (Carbofuron) and PII (Phorate).

Table 6: Leaching losses of different pesticides from different types of soil column

Treatments	µg per column (2012)	
	PI	PII
T_1-30DAA	409	185.9
T_2-60DAA	724.2	331.4
T3-90DAA	724.9	331.7
T4-30DAA	276.0	94.5
T5-60DAA	452.4	167.4
T6-90DAA	452.9	167.4
T7-30DAA	149.1	53.06
T8-60DAA	255.4	84.0
T9-90DAA	255.1	84.7
	SEm±	C.D.
soil type	8.08	31.1
soilXpest	11.4	43.99

Irrespective of the soil types it is observed that the pesticides residues content at 60 DAA and 90 DAA is nearly constant. This is due to the fact that the leachate was collected at an interval of seven days pooled and analyzed for pesticides content. In both the pesticides under study the pooled leachate of 42-49 days interval was detected but in the lecheate at 50-56 days no pesticides residue was detected.

The maximum leaching loss of pesticides was observed in Lateritic soils (7.41 to 11.14 percent of applied quantity) followed by Medium black soil (3.75 to 6.78 percent) and least in Coastal saline soil (1.88 to 3.82 percent) when the columns were kept for 90 days. Similar results were quoted by Redder *et al*., (1989) [24]. They reported that Lateritic soil column being a light textured soil with low CEC and higher infiltration rate favoured easy downward movement of applied pesticides as compared to Medium black and Coastal saline soil columns which have high CEC in Vertisol (Medium black and Coastal saline soil) possibly caused greater retention of pesticides. The leaching loss of pesticides were recorded less in Medium black and Coastal saline columns dominated by 2:1 type smectite clay minerals and red Lateritic soil dominated by Kaolinite type 1:1 type mineral. (Yaron 1978) [37].

The lowest value of pesticides in percolates of Coastal saline soil columns may be due to saline nature of the soils. Battala *et al.,* (2012) [5] observed that the rate of degradation of pesticides was faster by increase in soil salinity. The rate of degradation of pesticides to other form is quite faster in salt affected saline soil than non saline soil.

Among the pesticides (PI) and (PII) treatments under study, the Carbofuron (PI) recorded the higher (3.46 to 11.14 percent) leaching losses at all the sampling period over Phorate (PII) (1.88 to 8.24 percent).

Among the pesticides (PI) Carbofuron and (PII) Phorate under study treatments Carbofuron (PI) recorded the higher leaching losses at all the sampling period which were significantly superior over Phorate treated soil columns irrespective of soil type. This might be due to the fact that Phorate has lower solubility (22 mg litr^{-1}) as compared to Carbofuron (350mg litr^{-1}).

3.6 Effect of different treatment on persistence of pesticides at different depth of soil column.

The data pertaining to the downward movement behavior of pesticides (PI and PII) in different soil types was studied using soil columns. The mobility of applied pesticide residues in various soil types using soil columns at different depth of soil profiles viz. 0-30, 30-60, 60-90 cm as sampled after 30, 60 and 90DAA are presented in Table 7.

Table 7: Effect of different treatment on persistence of pesticides at different depth of soil column.

Pesticides residues µg kg^{-1}						
Treatment	0-30cm		30-60cm		60-90cm	
	PI	PII	PI	PII	PI	PII
T1-30DAA	1193	687	40	32	10	2
T2-60DAA	521	197	55	39	62	38
T3-90DAA	92	58	83	42	111	51
T4-30DAA	1414	816	25	21	6	3
T5-60DAA	669	286	51	31	43	33
T6-90DAA	96	75	71	36	82	40
T7-30DAA	1010	553	18	12	5	0.9
T8-60DAA	462	152	31	20	6	2
T9-90DAA	81	44	58	23	9	4
	SEm±	C.D.	SEm±	C.D.	SEm±	C.D.
soil type	11.59	44.5	1.79	6.88	4.09	15.76
soilXpest	16.39	63.0	2.53	9.73	5.79	22.29

Carbofuron (PI) and Phorate (PII)

At the depth of 0-30cm, the soil analysis the maximum Carbofuron (PI) and Phorate (PII)content at 30cm was observed in Medium black soil followed by Lateritic soil and the low in Coastal saline soil.

At the depth of 60-90cm The maximum Phorate (PII) and Carbofuron (PI) content was observed in Lateritc soill followed by Medium black soil and the low in Coastal saline soil.

The depthwise data of pesticides residues analysis of soil column indicates that that higher residue irrespective of soil type is observed at 0-30cm than compared to 30-60cm and 60-90 cm depth of soil column. Pesticide sorption was greater in surface horizons than in subsoil. Baskaran *et al*., (2010) [4]. It was also observed that the residue of pesticides decreased with increasing depth of the soils. More residues were accumulated at the top layers of the soil column.

Among the different soil types, the pesticides residues content was maximum in Medium black soil followed by Lateritic soil and Coastal saline soil at 0-30cm depth. However as the depth increased from 30-60cm and 60-90cm the Lateritic soil showed maximum residues content followed by Medium black soil. Coastal saline soil has minimum pesticides content as compared to other two soil types. The higher pesticides residues adsorption in smectitic rich soil was also recorded by Yaron (1978) [37]. He further concluded that residues content of pesticides increased with increasing swelling capacity of clay because of swelling type clay. Pesticides residues get absorbed in Smectite (2:1) type of clay structure in higher amount whereas the pesticides residues get adsorbed on the Kaolinite type in lower amount. Keiger and Yaron (1975) [14] concluded that soils which contain Smectite clay retain pesticides much more strongly than kaolinitic clays.

The higher pesticides residues at these two depths (30-60cm and 60-90cm) in Lateritic soil column might be due to accumulation of leached pesticides in the lower layer from upper layer of soil. The higher leaching rates of pesticides in Lateritic soil column and their accumulation in lower depth as compared to Medium black and Coastal saline soil was also reported by Reddar *et al.*,(1989) [24].

The data on pesticides residues at 30-60cm, 60-90cm depths reveals that as the number of days increased there was a gradual increase in the pesticide residues at all the soils under study in both the year of experiments. The increase in pesticides residues content was due to mobilization of pesticides residues with percolating water from upper layer to lower layer. Pesticides movement along with percolating water from upper layer to lower layer of soil increased the pesticicides residue accumulation at lower depths of soil.

As per the soil pesticides residues and movements of pesticides (PI and PII) in concern to the results revealed that soil column, the Carbofuron (PI) moves faster from upper layer to lower layer as compared to Phorate (PII) irrespective of soil type and the depth of soil column. This can be attributed due to low degradation rate and high solubility of Carbofuron of (350 mg litr^{-1}) as compared to Phorate (22 mg litr^{-1}). Bhuvaneswari *et al.,* (2011) [6] has reported that comparative degradation of Phorate and Carbofuron, Phorate is degraded at a faster rate which renders it unavailable for movement and the solubility of Carbofurom which is higher than the Phorate helps in its faster downward movement through percolationg water.

4. Reference

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