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Infiltration and Sorptivity Response to Application Rice-Husk-Ash Amendment of Loamy Sand Soil in Ikpa Basin, Nigeria

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Abstract: Field plot experiment investigated the effect which different methods of application of Rice-husk Ash (RHA) amendments (viz: RHA surface mulching (RHA-MUL) and RHA mixing (RHA-MIX)) with topsoil of loamy sand had on the soil's infiltration rate and sorptivity in a humid tropical environment. Data were obtained using double-ring infiltrometer from replicated plots analyzed using SPSS ver. 17 package for descriptive statistics, graphs, least squares regression and ANOVA. Paired sample statistics showed significant differences in infiltration rates between RHA-MIX and both the control soil and RHA-MUL, with the constant infiltration rate being significantly less, hence more water-saving in the RHA-MIX application than in both the control and RHA-MUL soils. Sorptivity and the accumulated infiltration also varied significantly. RHA-MUL did not show clear difference from the control soils. The least squares regression predicted the cumulative infiltration rate very accurately at R^2 = 0.997 and 0.998 in the two treatments although the RHA-MIX converged more gradually (longer elapse-time) to the constant infiltration rate than RHA-MUL. RHA-MIX method was preferable for loamy sands. RHA amendment benefited irrigation water savings in loamy sands due to resultant improvement in capillary flow in the filter media.

Keywords: Constant infiltration rate, loamy sands, RHA amendment, sorptivity, water-holding capacity

INTRODUCTION

Rainfall and Irrigation apply water, generally, by infiltration into the soil to improve water availability in the plants roots zone for plant consumptive use for metabolism, growth and yield. The success of irrigation depends on the availability of water in the soil pores for root extraction. Water availability in the soil depends on the water-holding capacity of the soil which is affected by texture and structure (Michael, 1978; Gupta and Gupta, 2008). Texture defines the pore size and influences the tendency of soil particles to aggregate into a soil structure. Soil texture and structure, amongst other factors, affect soil water-holding capacity (VICAIRE, 2011). Different soil textures have different water holding capacities which also affect the frequency of irrigation. Sand contains relatively large pore size favorable to a high rate of infiltration and is known to have the least water-holding capacity of about 50-110mm/m for coarse sands and 90-140 mm/m for loamy sands while clays, which have much smaller sized pores, have the greatest water-holding capacity (about 110-160mm/m) but the lowest infiltration rate (Michael, 1978; Smith, 2006; Gupta and Gupta, 2008). Therefore, lowering the loamy sand infiltration rate is a better approach to improving capillary water-holding capacity of soil.

Soil amendments, for instance, addition of organic matter increases infiltration rate and water movement substantially (Michael, 1978), but this increased infiltration rate may have disadvantage in homogenous sandy soils except the amendment is capable of in-filling the macrospores with fines to reduce macrospores paces or to increase microspores. However, the finer the grade of sand, the greater the increase in availability of moisture (Smith, 2006).

The choice of the application method that is to be used is experimental. However, Musy (2001) In: VICAIRE (2011) shows that homogenous soil covered by a crust has a comparatively lower infiltration capacity at time t than very porous soil without crust. Gupta and Gupta (2008) also showed that organic matter layering affect soil surface properties. Sandy loam is porous soil and RHA layer on it could act as a crust. The effect that such application method could produce is worth investigating. Also, mixing the fine-textured RHA with porous loamy sand is expected to affect the macropores of

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the sand; hence, this affects infiltration and water saving. Rice husk ash (RHA) is one locally available organic material that has high percentage of fines and is in abundance from small-holder rice - growers and small-scale processors in the wetland area of Enyong Creek (AKADEP, 1995); it possesses a large percentage of fineness of 62.5 - 77.7% of the size >45 μm and 22.3% of the size <45 μm fines (Essien, 2008); it has a density of 524 kg/m^3 and large specific surface area (145 m^2/kg) for attraction of water molecules for eventual root absorption; hence, it possesses a measure of effect on the capillarity (pore size) and water-holding capacity (Chopra, 1978; Shimizu and Jorillo, 1986; Mehta, 1994; Essien, 2008). Adding RHA, with its large percentage fineness and specific contact surface area, may affect the sandy soil texture depending on the in-washing of its finer materials into the voids in the sandy soil's profile. Therefore, two placement methods - surface-layered and direct mixing into the sandy soil are experimented. When the filter media is chocked with such in-filled fines, infiltration is reduced (Gupta and Gupta, 2008). Also in the case of surface-mulching, a dense compact layer of RHA may greatly limit the rate of downward movement of water before meeting the loamy sand surface underneath.

The application of the finer materials to increase microporosity in sandy soils is expected to benefit the upland soils of Ikpa river catchments in Nigeria's humid tropics, where the upland soils geology is weathered sandstone coastal plain sand having loamy sand texture in the 0-25 cm profile depth and loamy coarse sand or sandy clay loam below 50 cm depth in both the upland and terrace landforms, which gives it a USDA soil classification of Eutric Tropadult and Tropopsamment; and the sands and fines range between 80-75% and 7-8%, respectively (AKADEP, 1995; Udo, 1999). Marked water suction in the sands make upland dry season farming to suffer failure. Consequently rain-fed production has dominated the upland sands of Ikpa landforms while irrigation has not been applied fully even on few urban green patches. To sustain upland production of vegetables in the dry season, it is necessary to plan for irrigation in the sandy soils without wasting much agricultural water, as would be the case on mainly sandy soils; hence the imperativeness for the selection of placement method of soil amendment which can improve infiltration and conserve soil available water.

Hence the objectives of the investigation were:

- To apply RHA amendment both by surface mulching (RHA-MUL) and topsoil mixing (RHA-MIX) to the loamy sand soil
- To evaluate the sorptivity and infiltration responses to the soil amendment application methods.

MATERIALS AND METHODS

Experimental design: An incomplete block design with 3 beds placed side by side at 0.5 m spacing was replicated at the University Research farm with each plot size being 2×1 m^2. Plot 1 was the control; plot 2 had rice-husk-ash (RHA) mixed by hand to 5 cm of topsoil depth at the rate of 4 kg per plot (i.e., 2 kg of RHA/m^2). An earlier trial of 2 kg per (i.e., 1 kg/m^2) gave no significant change from the values for the control soil (Saadou, 2005). Plot 3 had RHA spread as surface mulch at the same rate of 2 kg/m^2, giving a uniform thickness of layered surface mulch. Thus, plot I was the control: plot 2 RHA-mixed and plot 3 was RHA -mulched amendment plots. Thereafter, soil bed was smoothened as required in rice cultural practice and infiltration rate measured. Infiltration test was carried out on them after determining the initial moisture content. RHA was prepared by Open-Heap Burning (OHB) procedure (Mehta, 1994).

Initial moisture content (IMC): Fresh samples of the soil were cut with soil auger to 10 cm depth in each plot and put into soil cans which were placed in an oven to dry at a temperature setting of 105ºC for 24 h. at the Soil Science Laboratory of University of Uyo, Uyo. The weights of the soil samples in the cans were recorded before oven-drying commenced and repeated after dry-cooling in desiccators. The difference between the weights of the fresh and dried samples gave the weight of the soil moisture in each soil sample.

Determination of soil texture: Soil texture of both the control and amended soil samples was determined using the hydrometer method, which is suitable for sandy soils with fines (Day, 1965; Klute, 1986) or ASTM D 422 - 63 (1990) method (Liu and Evett, 2000). The particle size distribution in percentages was obtained as in Day (1965).

Infiltration test: A double ring infiltrometer, with 30 cm and 60 cm inner and outer ring diameters, respectively, was used. The 30 cm and 60 cm-diameter rings were hammered into the soil to, at least, 15cm using timber pallet to protect the ring edge from damage during the hammering. Both rings were kept vertical and at the same height (Michael, 1978; Reddy, 2006; Raghunath, 2008). Water was quickly poured into the inner ring and the annular space between the two rings until a pondage depth of 7.0-12.0 cm and recording of drawdown started immediately. The time of starting the drawdown level and the time elapsed since starting were recorded. As the water level receded, replenishment was quickly added to bring the water level inside both rings back to approximately the original level. The refilled level and restart time were recorded and the drawdown measurement proceeded as before.

The test continued for infinite elapsed time until the rate of drop in water level was nearly the same at the same time interval. Readings were taken very frequently at 5-10 sec. at the beginning, then 1-2 min. after the first 5 min. thereafter, the interval was increased to 10-20 min. as the drop slowed down. The water in the annulus was expected to prevent lateral spread of water from the infiltrometer (Michael, 1978). The results were analyzed with SPSS ver. 17 statistical package for graph plots, the least squares regression and ANOVA and t-statistics for significant differences.

Theoretical review on relationship between sorptivity and infiltration rate: Infiltration event is governed by two factors: sorptivity and hydraulic conductivity, depending on the dryness or wetness of a given soil. Sorptivity (Sp) acts in the unsaturated soil and changes to a gravitational term called infiltration rate once the soil wets up (Reddy, 2006). The sorptivity factor is governed by the dryness or negative potential (matrix suction) of the soil. Thus, at the beginning of rain or irrigation, when the soil is still in its dry state, capillary attraction for moisture in the subsurface layer is very strong and impart a high initial value for infiltration (Reddy, 2006). The Philip's equation describing infiltration process composes infiltration capacity, I, as Chow *et al*. (1988). and www.nicholas.duke.edu (2011):

$$I = S_p t^{0-5} + F_c t \quad (1)$$

where, I is infiltration capacity or cumulative infiltration, S_p is sorptivity (cmhr $-^{1/2}$) and F_c is constant infiltration rate after an infinite elapse time for different soils and is influenced by the pore size, flow continuity and distribution of the rate of water flow through the soil under the influence of gravity for wet soil (NRES, 2006; Raghunath, 2008); It is the limiting infiltration rate in time, t, if the soil is saturated and homogenous (Bababe *et al.*, 2003; NRES, 2006; VICAIRE, 2011). Differentiating I in Eq. (1) with elapsed time gives the infiltration rate equation:

$$\frac{dI}{dt} = I_t = ½ \, S_p \, t^{-½} + F_C \quad (2)$$

Theoretically, if the change in rate is constant, then dI/dt is zero. Thus, dI/dt = o, implies that F_c is constant; hence S_p faction diminishes as t increases and tends to 0 as t tends to infinity. As time of application increases, the soil gets wetter, sorptivity vanishes leaving mainly the gravity-influenced constant infiltration rate (F_c) to dominate. The dryness of the topsoil will affect its rate intrinsically, hence the topsoil amendments will affect sorptivity and analysis will show how their different effects will be. Using the least squares method on cumulative infiltration vs time data,, infiltration rate is obtained by regression; S_p and F_c are estimated also by graphical plot of measured data (NRES, 2006). From Eq. (2), a plot of I_t -vs- $t^{-½}$ gives S_p as the slope at a given spectrum time. Also a plot of I-vs-t Eq. (1) will show two regions - the lower bound is the soil infiltration behavior dominated by sorptivity given as intercept, S_p, at any spectrum time prior to reaching the steady state region, while the steady state region indicates the saturated hydraulic conductivity, F_c given as the slope (Bababe *et al*., 2003). Therefore, S_p, F_c and spectrum time were obtained by both regressional analysis and graphical plots of field data.

Statistical analysis: Using SPSS ver. 17 package, field data were plotted against time either as infiltration rate versus time or cumulative infiltration versus time, where sorption coefficient and constant infiltration rate as t tends to infinity were obtained. Also, regression functions with their parameters were obtained. Using ANOVA or t-statistics, the infiltration rate, sorptivity and instantaneous infiltration under the different treatments and the control soil were also analyzed for significant differences.

RESULTS AND ANALYSIS

Results of texture changes and initial m.c. are given in Table 1 while infiltration rates variation with application method of RHA amendment are in Table 2. Initial m.c. was 15%.

Effect of RHA amendment on sandy texture:RHA increased the silt content of the original soil by 42% in both RHA-MUL and RHA-MIX amendment. The increase was significant, affecting porosity-based parameters like infiltration rate. The increase shows a significant effect of high RHA fineness. Clay content was reduced only in the RHA-MIX soil by 50% while sand was reduced by 3.0% in RHA-MUL soil and only 0.8% in RHA-MIX soil (Table 1). The slight reduction in percentage sand content in addition to the increase in silt content suggest that the filter media was chocked with fines especially with tamping or trafficking. The reduction in clay fraction suggests that in-filling of fines into the macrospores reduced colloids aggregation, hence made infiltration flow rate different from the original soil's hydraulic property (Gupta and Gupta, 2008).

Table 1: Soil texture affected by method of RHA application and pre-treatment initial moisture content

	Resulting soil texture			
Method of application	Sand, (%)	Clay, (%)	Silt, (%)	Initial m.c before infiltration test (%)
Original soil (CON)	89.9	4	6.2	15.48
RHA mulching (RHA-MUL)	87.2	4	8.8	14.97
RHA-mixing (RHA-MIX)	89.2	2	8.8	15.44

Table 2: Sample data of cylinder infiltrometer test on temporal variation of infiltration rate and cumulative infiltration for the control and RHA treatment soils

Time (min)	Cumulative infiltration (mm/min)	Time (min)	Infiltration rate (mm/min)
3	55	20	7.0
3	51	20	4.5
3	79	20	4.2
5	80		
5	68		
5	134		

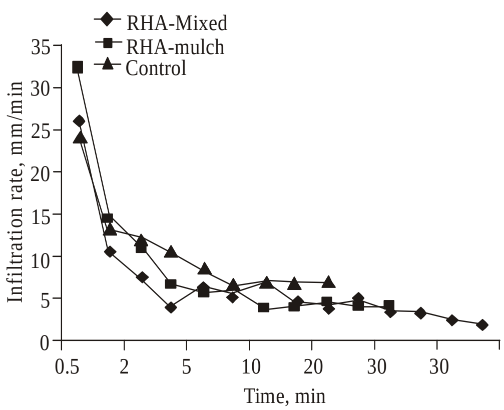

Fig. 1: Average Infiltration rate versus time for control, RHA-MUL and RHA- MIX

The mean infiltration parameters and standard error of the mean were computed from data on both the control soil and the modified soils. Figure 1 shows the comparative graphs of the measured infiltration rate (mm/min) versus time for both treatments and control soils. Table 2 indicates a wide dispersion on both cumulative infiltration and infiltration rate in the two treatment methods and the control soil although RHA-MUL, by ANOVA, indicated no significant difference @ $p<0.05$ from the control. The comparative infiltration (mm) versus elapsed time (min) for both treatments and control soils are shown in Fig. 2.

The mean values of I_t from the control and the modified soils data were determined from the horizontal asymptote to the I_t-vs-elapsed time's graph after an infinitely long elapsed time (Fig. 1) and showed mean infiltration rates of 10.64, 8.79 and 4.69 mm/min for the control, RHA-MUL and RHA-MIX treatment soils respectively. RHA- MIX had the lowest constant infiltration rate.

Analysis of variance statistics: Paired-sample t-statistics and the levels of significant difference were computed for the treatments or different applications of amendments and the control regarding infiltration rate. They are displayed in Table 3. In the cases of:

- Control and RHA-MUL
- Control and RHA-MIX
- RHA-MUL - RHA-MIX

significant differences existed between groups of treatments and the control. There was a significant difference ($p<0.01$) between control and RHA-MIX soils from the paired sample t-test (Table 3) while RHA-MUL and RHA- MIX showed significant difference at $p<0.1$, although RHA-MUL and control had no significant difference @ $p\leq 0.05$. Thus, the hypothesis that the values of the infiltration rate of loamy sand was modified (reduced) by the RHA-MIX treatment was accepted at $p\leq 0.05$. Thus, the soil amendment methods produced distinct quantitative effects on the infiltration rate of the loamy sand soil.

DISCUSSION

Infiltration is a process of water intake into the soil, generally by downward flow through all or part of the soil surface. It is important in taking water to the rootzone from the soil surface to sustain green vegetation, agricultural and food production and ground water recharge. But in the dry season under irrigation green vegetation, agricultural and food production are the main concerns.

Infiltration has a rate of entry to soil as it is, in generic term, the volume of water that enters the soil per unit ground surface area per unit time or specifically, the depth of water per unit area. The rate can be supply - or soil-controlled (www.nicholas.duke.edu, 2011). If all the water, probably, enters the soil system when a small quantity of water is sprinkled on the soil, then such infiltration process is governed by the amount of water applied, hence such water intake rate or the process is supply - controlled. However, if precipitation rate is so

Table 3:Paired samples t -test for treatment and control soils with RHA

Paired samples		Paired differences							
					95% Confidence interval of the difference				
		Mean	SD	SEM	Lower	Upper	t	df	sing.(2-tailed)
Pair 1	control - RHA-MUL	0.78889	3.66386	1.22129	-2.0274	03.60518	0.646	8	0.536
Pair 2	control - RHA- MIX	2.39556	2.340	180.78006	0.5967	34.19438	3.071	8	0.015
Pair 3	RHA-mulch - RHA-MIX	1.28727	2.39560	0.72230	-0.3221	12.89666	1.782	10	0.105

high during flooding events that it exceeds the ability of the soil to transmit this water at the high rate, then resultant infiltration rate is “soil-limited” or soil-controlled (www.nicholas.duke.edu, 2011).

Effect of RHA on initial infiltration rate: From the graphical plot of infiltration and time data, the infiltration rate at the initial one minute of the water intake was very high. RHA-MUL had 192 cm/hr as the highest initial rate compared to 156cm/hr for RHA-MIX and 144 cm/hr (the lowest) for the control soil. Thus, the RHA amendment and mode of application (RHA-MUL, RHA-MIX) actually increased the amended soil’s initial water intake rate above the control soil by 33% and 8%, respectively. The tendency of organic amendment to increase moisture uptake in the first few minutes of water application was observed in Bababe *et al.* (2003) in Maiduguri sandy loam, where an increase of 29% above the control’s initial intake was recorded. This effect could be linked to the RHA amended soil’s texture. It was observed that RHA-MUL, which had 3% reduction of sand content and 42% increase in silt content from the original soils texture, increased its initial infiltration rate by 10%, while the RHA-MIX mode, which reduced original soil’s clay content by 50% and increased its silt content by 42%, increased the initial infiltration rate by 33% (or two-thirds of the original soil’s rate or about 4 times the change by RHA-MUL’s method). Thus, the RHA-organic soil amendment method modified loamy sand soil’s texture which increased initial water intake rate by 33% for surface-mulching and 8% for soil-mixing methods respectively.

Effect of amendment on cumulative infiltration: Using the field data, the accumulated infiltration capacity I, on the field plots was obtained as an exponential regression function for each treatment and control soil using SPSS ver 17 package for the graph of cumulative infiltration versus elapsed time (Fig. 2) as in Michael (1978) and Reddy (2006). The line of best fit for each application method of amendment was as follows:

For CONTROL, $I = 1.7t^{0.76} + 0.22$, $R^2 = 0.998$ (3)

For RHA - MUL, $I = 0.66t^{0.94} + 0.65$, $R^2 = 0.997$ (4)

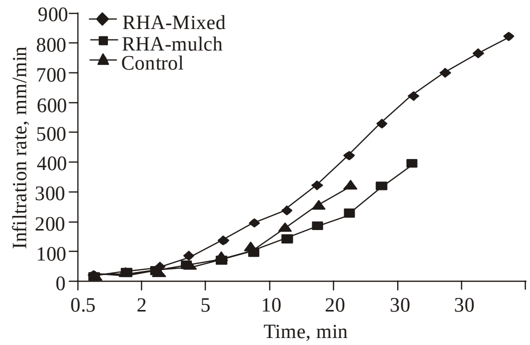

Fig. 2: Average cumulative infiltration rate versus time for control, RHA-MUL and RHA- MIX

For RHA - MIX, $I = 0.46\ t^{0.99} + 1.26$, $R^2 = 0.982$ (5)

where, I is the infiltration capacity or infiltrated volume per unit area, mm; t is the elapsed time, min and R^2 is the coefficient of determination for treatments. The equations are in form of Philip’s equation. The very high coefficients of determination (R^2 = 0.98-0.99) indicate a very good fit in the exponential regression; and showed that the variations in the cumulative infiltration could be explained completely by the resultant soil texture of RHA-MUL and RHA-MIX treatments and the control.

The depth of infiltered water in the first one hour depended on the amendment and application method and indicated whether or not water loss through infiltration could be reduced (i.e., water conserved) in sandy textures. From Eq. (3) to (5), the depth of infiltered water after 1 hour was obtained as 38.40 mm in the Control texture; 31.62mm in the RHA-MUL and 27.75 cm in the RHA-MIX mode which is up to 17.6% of RHA-MUL and 27.73% of the Control’s value. Thus, although loamy sand loses much water in the field during irrigation application, mixing the topsoil with RHA reduces this water loss (hence conserved water) for root zone use by 27.73% of the original loamy sand’s value. Also, the RHA-MUL (for mulching mode amendment) reduces less by 17.66% of the control value. Hence, RHA amended soil also acts as water conservation medium in sandy soils, which ordinarily has high loss of infiltered water. In such a case, the rate of application of water in loamy sand can be reduced, thereby conserving irrigation water.

Table 4: Estimate of mean and expected infiltration capacity, sorptivity and spectrum time

Parameter	Control	RHA-MUL	RHA-MIX
Mean cumulative infiltration, mm1	36.40	95.56	430.90
Estimated cumulative infiltration, mm	136.41	76.702	236.60
Sorptivity mm min$^{1/2}$	-0.114	-28.71	-4.76
Spectrum time, min	14.40	3.16	6.60

The unit is in mm (not cm)

Instantaneous infiltration rate, I_t: Differentiation of the accumulated infiltration Eq. (3) to (5) with respect to elapse time gave the respective instantaneous infiltration rates (Bhattacharya and Michael, 2003) for each treatment and became constant rate at a sufficiently long time.

From Eq. (3) to (5), the instantaneous infiltration rates I_t were obtained as the following differential equations which conform with Kostiakov physically-based model (VICAIRE, 2011):

$$\text{For Control, } I_t = 1.2924t^{-0.24} \quad (6)$$

$$\text{For RHA - MUL, } I_t = 0.6204t^{-0.06} \quad (7)$$

$$\text{For RHA - MIX, } I_t = 0.4554t^{0.01} \quad (8)$$

where, $I_t = dI_t/dt$ = infiltration capacity.

Their slopes are significantly close with the slopes in the corresponding Eq. (3) to (5), but the exponents are not; I_t is the instantaneous infiltration rate, mm/min and t is elapsed time, min. and the coefficient of the exponential functions are the sorption coefficient (www.nicholas.duke.edu, 2011). At 1 hour the infiltration rates were Eq. (6) to (8): 1.171mm/min for the control, 0.485 mm/min for RHA-MUL and 0.437 mm/min for RHA-MIX. The sorption coefficients and the exponents differed, showing that the sorption or the soil capacity to absorb water when the flow is produced only under gradient pressure (Musy, 2001; VICAIRE, 2011) varies with the soil amendment and the method of application of soil amendment. The infiltration rates at t = 1min (i.e. instantaneous infiltration rate) was highest in the control (1.292 mm/min), medium in RHA-MUL by half of the control (0.620 mm/min) and low in RHA-MIX (0.455 mm/min) almost one-third of the control value. This shows that controlled spectrum of water absorption on porous sandy loam is exhibited by both treatments with RHA-MIX having more controlled absorption than RHA-MUL; hence, water distribution and conservation is guaranteed especially by RHA-MIX methods of amendment application on loamy sand soil, which ordinarily waste irrigation water.

Sorptivity, mean infiltration rate: The plot of cumulative infiltration versus $t^{1/2}$ was made; and the average infiltration, estimated cumulative infiltration, sorptivity and its mean spectrum time were computed. The results are given in Table 4. Values in Table 4 show that RHA- MIX has the highest infiltration capacity followed by control soil, while RHA-MUL has the smallest. It appears that the surface layer of RHA-MUL acted as a clogging crust on the sand surface. The sorptivity was very high at 28.71 mm/min at early spectrum time for RHA-MUL whereas it was very low for RHA-MIX even at a higher spectrum time of twice the value for RHA-MUL. Sorptivity dominated the flow up to 6.6 min in RHA-MIX and 3.16 min in RHA-MUL whereas capillary forces were remarkably reduced in the macropores of control soil (loamy sand) to -0.114 even at 14.4 min. Thus, more gravity supply is needed in control at 14.4 min but well conserved capillary water in the treatment.

In the wet soil, surface tension is the most important force, while in the dry range, absorption (or sorptivity) is the main factor. When water is present in fine capillaries, the energy with which it is attached is a function of surface tension and capillary size but when it is present in bigger pores, it is bound loosely to the soil and can be acted upon (drain easily) by gravity (Michael, 1978). Thus, the higher sorptivities in RHA-MIX and RHA-MUL show capillary pore reduction in them from macropores of control soil and indicate a higher water-holding effect in the treatment soils on irrigation than the control. Hence RHA-modified loamy sand has higher soil water conservation than the control soil.

Thus, using RHA-MUL and RHA-MIX enables the modified loamy sand to hold much more amount of moisture even at the high tensions to prevent plant wilting at such tension that it will wilt under solely loamy sand. Plot of cumulative infiltration capacity versus $t^{1/2}$ (square root of elapsed time) (Fig. 3, 4 and 5) gave the linear predictive functions of cumulative infiltration capacity for the two treatments and the control and their gradient as the sorptivity. Their coefficients of determination were high with R^2 = 0.873, 0.915 and 0.935 for the control, RHA-MUL and RHA-MIX, respectively, indicating that the ability to predict the soils infiltration capacity under the different treatments were efficiently modeled by the linear functions especially for the treatments. The RHA-MIX had the highest prediction efficiency.

RHA amendment on constant infiltration rate: The effect of texture on a dry soil indicates that water infiltrates into the surface layers of the soil through both the large gravity channels and by direct capillary action

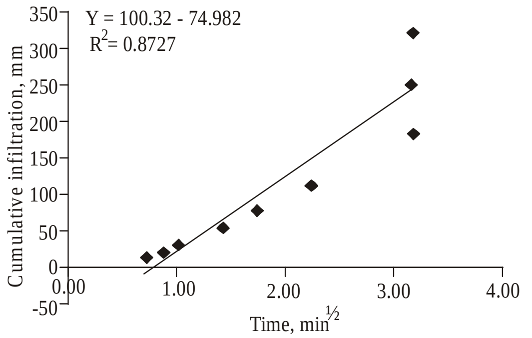

Fig. 3: Graph of cumulative infiltration vs square root of time for control

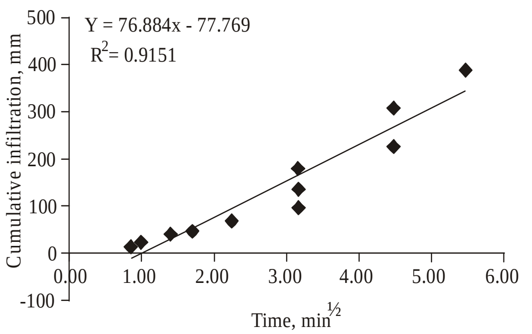

Fig. 4: Graph of cumulative infiltration vs square root of time for RHA-MUL

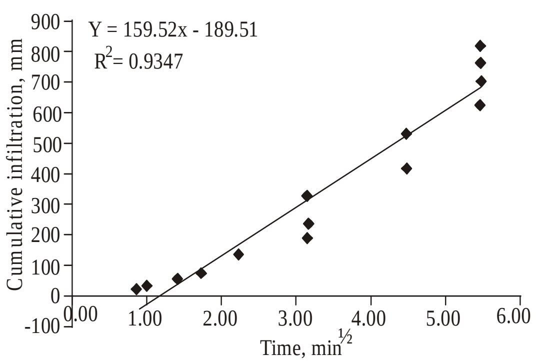

Fig. 5: Graph of cumulative infiltration vs square root of time for RHA-MIX

over the surface area. As the capillary pores get filled, a progressive reduction in infiltration rate occurs until steady conditions are attained, at which point a constant infiltration rate results which is equal to the percolation rate of the underlying soil layer (Gupta and Gupta, 2008). The RHA mulch thickness acted as a dense vegetal cover, increasing infiltration due to its protection of the sandy soil's surface from mechanical compaction and holding down the water into the soil surface, thereby resisting it from forming runoff. This justifies the higher initial infiltration rate of the amended soil compared to the ordinary loamy sand.

The RHA reduced compaction and water absorption at the soil surface which combined with the relatively large sand pores below it, (hence reduced capillary effect) to make RHA-MUL attain the highest initial infiltration rate and a constant infiltration rate which was less than the value for the control soil but faster than the value for RHA - MIX amendment. The method of RHA-MIX produced a lower initial infiltration rate than RHA-MUL and the lowest steady state infiltration rate among the treatments and control.

CONCLUSION

Field investigation by plot experiment was performed with Rice-Husk Ash (RHA) amendment to observe the effect of the two methods of application: RHA surface mulching (RHA-MUL) and RHA mixing (RHA-MIX) on the infiltration parameters and sorptivity of the amended loamy sand soil. The rates of 2 and 4 kg/m^2 were experimented and data analyzed for constant infiltration rates, cumulative infiltration, sorptivity and spectrum time using SPSS ver 17 package. The RHA amendment improved loamy sand infiltration rate and infiltration capacity and water holding capacity was significant in RHA-MIX compared to high soil matrix suction in control soil ($p \leq 0.05$). The constant infiltration rates under RHA-MIX (soil incorporated) treatment were significantly less, hence more water- saving in the rootzone, than both the control's and RHA-MUL (surface spreading) method and the RHA-MIX had the highest infiltration capacity and sustained infinite variation in intake towards convergence at infinite elapsed time. This sustains soil water conservation in the loamy sands. Sorptivity differed between them at different spectrum times.

The least square regression for cumulative infiltration with elapse time gave accurate predictions at R^2 = 0.982-0.998 for both the control and the treatments. RHA amendment was advantageous in reducing wasteful high water intake rates, hence conserving water resources for irrigating on loamy sands. RHA-MIX amendment method is recommended.

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