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Clogging Test of Drippers Watered by Surface Water Treated with Natural Coagulants and Suitability of this Water for Drip Irrigation

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Abstract **Original Research Article**

In the Sahel, rainfall deficits have been recorded increasingly in this portion of Africa over the last 4 decades. This situation has resulted in a remarkable decline in agricultural production and peasant income in Niger. Indeed, agriculture is essentially rain-fed, therefore sensitive to rainfall hazards. It is in this climatic context unfavorable to rainfed agriculture that the State is placing increasing emphasis on surface water with a view to developing intensive and diversified irrigated agriculture. This work aims on the one hand to analyze the hydraulics of the drippers and on the other hand to test products based on Moringa oleifera seeds (powder and cakes from these seeds) in the treatment of surface water in order to improve the physico-chemical and bacteriological qualities of the latter for use in drip irrigation systems. The methodology consists of measuring the water coming from the drippers after each irrigation. To compare the suitability of treated water in a drip irrigation system, three (3) irrigation networks were set up. The hydraulic operation of the latter was previously verified using tap water from the urban distribution network of the city of Niamey on the experimental site of the Faculty of Agronomy of Niamey. The comparison concerned water treated with almond cake and Moringa oleifera almond powders and raw water from the study pond. By carrying out irrigations for 1 hour per network made up of four (4) booms with a total of 24 drippers or 6 drippers per boom. The comparison of the different valve volumes, boom holder volumes, boom volumes, dripper volumes show that at the same pressure, the volumes obtained with treated water are statistically identical to the reference volumes established with tap water. On the other hand, the raw water presented volumes lower and statistically different from the volumes of water mentioned above. This reduction in volume is the consequence of clogging by particles suspended in this network. The treatment of raw water treated with almond cake and *Moringa oleifera* almond powders made it possible to have water suitable for drip irrigation.

Keywords: Sahel, Rainfall Deficit, Drip Irrigation, Moringa Oleifera, Water Treatment.

INTRODUCTION

The constant increase in agricultural water needs, combined with conflicts of use with other sectors, such as industry, tourism and drinking water consumption, require us to constantly think about saving water and resources. 'energy. Indeed, in arid or semi-arid countries like Niger, with climate change where the variability of meteoric water supplies is very pronounced, there is reason to consider the introduction of energy-saving irrigation systems. Water at the expense of the water-wasting gravity system. This will necessarily involve integrated and effective management of irrigation as well as control of the use and choice of irrigation systems (Hasna *et al*., 2011). Indeed, the drip irrigation system seems best suited to these listed constraints.

Chemical water treatment with aluminum sulfate is frequently used for irrigation water as well as for consumption. The use of this flocculant is not without consequences. In fact, the latter is toxic and generates an accumulation of residues in the treated water.

This study was carried out on the experimental sites of the Faculty of Agronomy of Niamey. In this case, the aim is to assess the suitability for irrigation of pond water treated with natural coagulants derived from *Moringa oleifera* seeds and raw water from the same pond by highlighting a possible physical clogging of the drippers fed by these different waters. Indeed, currently, the main methods for evaluating the performance of drip irrigation systems consist of measuring the flow rate of the drippers and counting the total number of blocked drippers (Duran-Ros *et al*., 2009, Li *et al*., 2009, Puig-Bargués *et al*., 2010).

MATERIAL AND METHODS

Dripper clogging and/or clogging test

Experimental device

The test on the clogging of drippers in a drip irrigation system consists of testing the irrigation water distribution drippers using an experimental device. The dripper clogging test consists of measuring the nominal flow rate of 72 drippers. For this purpose, 3 sources of irrigation water were used to supply 3 drip irrigation networks. These sources of irrigation water include:

- The first source of water is Raw Water (EB) from the Kongou Gorou pond supplying the R1 network;
- The second source is pond water treated with Almond Powder (EPA) which serves the R2 network;
- And finally the raw water from the study pond treated with Almond Cake Powder (EPTA) watering the R3 network.

Each of these networks is made up of 4 booms 7m long, each equipped with 6 integrated drippers spaced 0.5m apart, delivering a nominal flow rate of 1l/h. The spacings between ramps are also spaced 0.5m apart.

At each dripper, a device for recovering water from the dripper has been installed. It was a cylindrical hole 10 cm in diameter and 42 cm deep. In each hole, there is a 1.5l bottle fitted with a funnel to collect the water coming from the dripper during irrigation.

The water supply to the R2 and R3 irrigation networks comes from the treatment tanks and that of the R1 network is made with raw water from the pond. From the bottom of these tanks, 20cm from the bottom of each of them is placed a tap (valve) to transfer the treated water into the 3 supply tanks (EB = R1, EPA = R2 and EPTA = R3).

The treatment tanks contain raw water from the study pond + Coagulants (cake powder and almond powder).

For R2: Raw water + *Moringa olifera* seed almond powder (EPA)

For R3: Raw water + *Moringa olifera* seed cake powder (EPTA)

These mixtures of raw water with the coagulant are agitated in two successive stages to ensure good flocculation: rapid agitation and a second which is slow. The first agitation, energetic and of short duration, consists of making 160 revolutions per minute for 2 minutes to disperse the products throughout the entire volume of water. The second, relatively slow stirring is done at a speed of 60 revolutions per minute for 20 minutes to promote flocculation of suspended particles (Jahn, 1988a; Kaboré, 2013).

The raw water treatment tanks are placed 2m from the ground. A 1.5m high platform is set up to facilitate stirring of the water-flocculant mixture. 20cm from the bottom of the treatment tank, a tap is placed to transfer the treated water into the irrigation water supply tank.

Twenty (20) irrigations including two (2) per week were carried out. These irrigations last 2h30 including 1h of irrigation itself and 1h30 devoted to measuring the flow rates and volumes of water coming from the drippers and 3 irrigations networks.

From the 1st to the 20th irrigation, we will always determine the volume of irrigation water for :

- The 3 networks (24 drippers).

¬The second step consists of detecting possible clogging and/or blockage at the level of the drippers.

At the Level of the Drippers:

Given the number of drippers on all the networks (72) and that of irrigations (20 in total), we chose to follow drippers 1, 3 and 6 of ramps 1 and 3 of each network. The choice of these three (3) drippers is justified by the fact that dripper 1 is at the head of the boom, dripper 3 in the middle and 6 at the end of the boom. In addition, 3 heights were considered for the measurements, these are h1 = 0.53m, h 3 = 0.336m and h5 = 0.155m.

The clogging of the drippers will be highlighted through measurements of irrigation water volumes and then observations.

RESULTS AND DISCUSSION

RESULTS

This involves comparing the data obtained during irrigations carried out with treated water and drinking water from the Nigerien Des Eaux (NDE) network which is water without any problem with drip irrigation. This NDE water will be considered in the case of this study as reference water.

Clogging check

¬At the level of the irrigation water network treated with almond cake powder (EPTA)

For the water height h1= 0.53m, the network reference volume is 21917ml compared to 21890ml, 21874ml, 21890ml and 21905 of the volumes obtained during irrigations 1; 6; 11 and 16. We note non-significant decreases in volume compared to the drinking water reference volume of the NDE. These are 27ml, 43ml, 27ml and 12ml at the irrigations carried out (1; 6; 11 and 16). However, these observed decreases are also negligible.

Considering the water heights in the reservoirs, the findings are the same at heights h3 and h5. The reductions recorded are a few milliliters:

- 58ml, 38ml, 23ml and 43ml at respective irrigations 3; 8; 13 and 18;
- 72ml, 52ml, 47ml and 22ml at respective irrigations 5; 10; 15 and 20.

¬At the level of the irrigation water network treated with almond powder (EPA)

For the water height h1 = 0.53 m, the network reference volume recorded during irrigations with NDE water is 21949 ml compared to 21927 ml, 21884 ml, 21865 ml and 21830 of the volumes obtained during the irrigations 1 ; 6 ; 11 and 16. As in the case of almond cakes, there are reductions in volume compared to the network reference volume. They are 27 ml, 65 ml, 84ml and 119 ml (0.54%). However, it should be noted that these regressions are insignificant.

As in the first case, we compared the volumes of water obtained from irrigations as a function of the height of water in the reservoir. The heights considered are h3 and h5. Insignificant decreases are recorded and are:

- 46 ml, 41ml, 26 ml and 46 ml at respective irrigations 3; 8; 13 and 18 ;
- 36 ml, 26 ml, 31ml and +22 ml (increase) at respective irrigations 5; 10; 15 and 20.

¬At the level of the irrigation network watered with raw water from the pond (EB)

We note that, whatever the water pressure considered, the volumes obtained during irrigations with raw water from the pond are clearly distinguishable from the reference volumes of the networks, particularly at the level of irrigations 11 and 16. Indeed, at the water height h1= 0.53m, the reference volume of the NDE drinking water network is 21929 ml compared to 21950 ml, 21905 ml, 18600 ml and 17020 ml obtained respectively during irrigations 1 ; 6 ; 11 and 16.

The difference observed between the reference water volume of the NDE (drinking water) and the volumes generated by these irrigations increases from the first to the last irrigations (15.18% to 22.38%). Decreases in volume were also recorded in relation to the corresponding pressures at the respective heights h3 and h5.

These reductions are:

- 97ml, 1232 ml (6.36%), 2082 ml (10.75%) and 3575 ml (18.52%) at respective irrigations 3; 8; 13 and 18;
- 33 ml, 778 ml (4.48%), 2688 ml (15.48%) and 4613 ml (26.57%) at respective irrigations 5; 10; 15 and 20.

Table 1 gives the average water volumes obtained during irrigations 1, 6, 11 and 16 at the level of networks 1,2 and 3 depending on the treatments at water height in the reservoir h1 = 0.53 m. In this table, we note that the volumes obtained during different irrigations are almost equal for all treatments except for irrigations 11 and 16 carried out with raw water from the pond. These reductions are significant and range from 17020 ml (raw water) to 21931.33 ml (NDE) for the 16th irrigation and from 18600 ml (raw water) to 21931.33 ml (NDE) for the 11th irrigation.

Table 1: Average water volumes obtained from the networks according to the treatments at height h1= 0.53m during irrigations 1; 6; 11 and 16

Modality	Average estimated	Groups				
I16*EB	17020,000	A				
I11*EB	18600,000		B			
I6*EPA	21874,000			C		
I6*EPTA	21885,000			C		
I1*EPTA	21890,000			C		
I11*EPTA	21890,000			C		
I6*EB	21905,000			C	D	
I16*EPTA	21905,000			C	D	
I16*EPA	21905,000			C	D	
I1*EPA	21927,000				D	
I1*NDE	21931,667				D	
I11*NDE	21931,667				D	
I16*NDE	21931,667				D	
I6*NDE	21931,667				D	
I1*EB	21950,000					E
I11*EPA	21975,000					E

The Table 2 gives the average water volumes of networks 1, 2 and 3 obtained during irrigations 1, 6, 11 and 16 depending on the treatments at the water height in the reservoir h1 = 0.53 m. It appears from this table that the volumes of water obtained from the tasters of the EPTA, EPA and NDE treatments are statistically equal.

On the other hand, the volume obtained in the network watered by raw water differs significantly from three other volumes (EPTA, EPA and NDE), with a difference of 2062.92 l between the NDE and EB treatments.

Table 2: Average water volumes obtained from the networks depending on the treatments during irrigation at h1= 0.53 m

Modality	Average estimated	Groups	
EB	19868,750	A	
EPTA	21892,500		B
EPA	21920,250		B
NDE	21931,667		B

The Table 3 gives the results of the test comparing the water volumes of the networks according to treatments 2 to 2 during irrigation at h1 = 0.53 m.

Considering the EB-NDE, EB-EPTA and EB-EPA treatments, we note that the p values are all less than 0.0001 and therefore are even smaller than 0.05, thus showing a highly significant difference between these treatments.

In other words, the averages of the processing volumes concerned are not the same. Thus, the multiple comparison of the results shows that the average of the EB treatment is the only one to be significantly lower than that of three other treatments. On the other hand, the comparison of the EPA-NDE, EPA-EPTA and EPTA-NDE treatments indicates statistically identical volumes.

Table 3: Results of the 2 to 2 comparison test of the water volumes of the networks according to the treatments during irrigation at h1 = 0.53 m

Contraste	Pr > Diff	Significatif
EB vs NDE	< 0,0001	Oui
EB vs EPA	< 0,0001	Oui
EB vs EPTA	< 0,0001	Oui
EPTA vs NDE	0,899	Non
EPTA vs EPA	0,539	Non
EPA vs NDE	0,087	Non

The Table 4 illustrates the average water volumes of networks 1, 2 and 3 obtained during irrigations 3, 8, 13 and 18 depending on the treatments at water height in the reservoir h3 = 0.336. For NDE water, almond meal powder (EPTA), almond powder (EPA), no significant difference is observed in the volumes of water obtained from the networks during the irrigations carried out. However, for the volume recorded with the network supplied by raw water, there is a significant reduction in volumes compared to the volumes of three other treatments. This regression goes from 19324.14 ml (NDE) to 18055.67 ml (EB).

Table 4: Average water volumes obtained from the networks depending on the treatments during irrigation at h3= 0.336 m

Modality	Average estimated	Groupes	
EB	18055,667	A	
EPTA	19293,333		B
EPA	19323,750		B
NDE	19324,139		B

The Table 5 gives the average water volumes of networks 1, 2 and 3 obtained during irrigations 5, 10, 15 and 20 at water height in the reservoir h5 = 0.155m depending on the treatments. It appears from this table that there is no significant difference in the volumes of water obtained during irrigation with NDE water, treatments with almond cake (EPTA) and almond cake (EPA). On the other hand, we note a considerable reduction in volume obtained with the network supplied with raw water. This decrease goes from 17368.72 ml l (NDE) to 15331.58 ml (EB).

Table 5: Average water volumes obtained from the networks depending on the treatments during irrigation at h5 = 0.155 m

Modality	Average estimated	Groups	
EB	15331,583	A	
EPTA	17322,500		B
EPA	17361,417		B
NDE	17368,722		B

The Table 6 gives the results of the test comparing the water volumes of the networks according to treatments 2 to 2 during irrigation at h5 = 0.155m of networks 1, 2 and 3.

Considering the EB-NDE, EB-EPTA and EB-EPA treatments, we see that the p values are all less than 0.05 ($p<0.0001$), which indicates a highly significant difference between these treatments. This means statistically that the volume averages of three treatments are not identical. By comparing the results of the averages, it is noted that the average obtained at the EB treatment level is significantly lower than the 3 other averages.

For the EPA-NDE, EPA-EPTA and EPTA-NDE treatments, the respective p-values are 0.103; 0.265 and 0.534 and therefore greater than 0.05. Which means that there is not a significant difference in the volumes obtained with these treatments, this shows that their volumes are statistically identical.

Table 6: Results of the test comparing the water volumes of the networks according to treatments 2 to 2 during irrigation at h5 = 0.155 m

Contraste	Pr > Diff	Significatif
EB vs NDE	< 0,0001	Oui
EB vs EPA	< 0,0001	Oui
EB vs EPTA	< 0,0001	Oui
EPTA vs NDE	0,534	Non
EPTA vs EPA	0,265	Non
EPA vs NDE	0,103	Non

The different statistical results obtained with the networks, confirm, as in the two previous cases, a physical clogging by irrigation with raw water and irrigation without any problem if they are carried out with pond water treated with water powders almonds and *Moringa oleifera* cake.

DISCUSSION

Irrigations with water treated with almond cake powders and that using raw water from the Kongou Gorou Zarmagandey pond were carried out in the present study to, on the one hand, study the clogging of the drippers and on the other hand to evaluate the suitability for drip irrigation of this water treated with coagulant powders from *Moringa olifera* seeds (almond cakes and almonds). Drippers 1, 3 and 6 of the networks supplied by these powders delivered flow rates identical to the respective reference flow rates obtained during irrigation with NDE water whatever the height considered (h1 = 0.53m h3 = 0.336m or h5 = 0.155m).

This shows that this water obtained has, following treatment, acquired characteristics favorable to drip irrigation; in other words, this water does not present any risk of physical clogging, let alone blocking the drippers, and is suitable for pressure irrigation systems, particularly localized ones.

This illustrates the effectiveness of the two natural coagulants from Moringa oleifera seeds in the treatment of murky water such as pond water. This effectiveness of *Moringa oleifera* seeds has been confirmed by several authors including Kaboré *et al*., 2013 in Burkina Faso, Noureddine (2015) in Algeria, Rakotoniriana (2015) in Madagascar.

On the other hand, if we consider the distribution of raw water with these same drippers during irrigations, a significant reduction in the volumes of irrigation water was recorded at the level of 3 drippers for all water heights in the reservoir particularly from irrigations 11, 8 and 10. These reductions in water volumes reflect an obvious physical clogging of these drippers supplied by raw water from the study pond. These results are in agreement with the work of Jueying (2014) who concluded that clogging in the emitters leads to a reduction in the average flow rate as well as a reduction in the uniformity of flow rates along the pipe.

These results are also confirmed by Zaghluol *et al*., (2014) who, using raw surface water containing suspended particles, had GR on line drippers and Button on line drippers which were clogged.

By using raw water during irrigation, the observed physical clogging of drippers 1, 3 and 6 of booms 1 and 3 could be explained by the existence of suspended matter or clay particles which would have clogged these drippers. This clogging of said drippers can be verified at the level of the network made up of 24 drippers supplied with the same raw water.

Turning now to the networks, it appears that the networks supplied by water treated with almond cake and almonds are identical to the NDE reference networks and differ from the network supplied by raw water. Considering for example the height of water in the reservoir h5 = 0.155m and the 15th irrigation, the difference in terms of quantity of water between the almond cake network and the reference network (supplied by water from the NDE) is 0.11 to 0.22%. On the other hand, this difference is 15.55% between the reference network and raw water network. For the 20th irrigation and at the same water height, the difference between networks with water treated with moringa-based products and the reference network still remains very low (0.16 to 0.19%).

Considering the height h3= 0.336m and the 18th irrigation, the differences recorded between the water volumes of the networks supplied by treated water (EPTA and EPA) and the reference network on the one hand and between the reference network and the raw water network on the other hand are respectively 0.04% to 0.14% and 15.52%; but the relative difference in water volume between the reference networks and raw water increases to reach 26.53%. It clearly appears that the differences in water volume between the reference networks and raw water are observable whatever the pressure considered.

The absence of physical clogging of the networks supplied by the treated water shows that this water is suitable for irrigation with the pressure irrigation system which here is drip. This also shows the effectiveness of *Moringa oleifera* seed derivatives (Almonds and Oilcake) in the treatment of surface water as highlighted by Mougli *et al*., (2005). The results of our work also match those obtained by Diallo in Guinea

Conakry (2008), Siddo (2018) in Niger, Koto-té-Nyiwa (2015) in the Democratic Republic of Congo (DRC), Fatombi (2007) in Benin and of Emilie *et al*., (2007) in Mozambique.

CONCLUSION

The aim of the present study was to study the suitability of water treated with almond powder and Moringa oleifera seed cake for drip irrigation. Tests on irrigation with this water and raw water from the Kongou Gorou Zarmagandey pond were carried out experimentally under different pressures. Irrigation carried out with networks supplied by water treated with almond cake powders does not show any physical clogging or blockage of the drippers. Indeed, drippers 1, 3 and 6 chosen at ramps 2 and 4 of each network delivered flow rates identical to the respective reference flow rates obtained during irrigation with NDE water whatever the water height in the reservoir considered.

This testifies to the good quality and suitability of this water treated with the two natural coagulants from the seeds of Moringa oleifera mentioned above to conduct irrigation with the drip irrigation system. On the other hand, the irrigations carried out at the level of the network supplied by raw water from the pond of the Kongou Gorou pond, show a clear dysfunction of the latter by recording a significant decrease of the order of 15, 52 to 26.53% of the irrigation water volumes at the level of 3 drippers for all water heights in the tank considered. The use of raw water from said pond in drip irrigation causes clogging of the drippers and is also verifiable at the level of the ramps and the network made up of 24 drippers.

Authors' Contributions: This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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