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Water Saving in Crop Production in the Humid and Semi-Arid Tropical Regions by Optimal Compost Applications

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Abstract: Water saving technology interests crop producers in both the humid and semi-arid regions of the tropics. Although water saving does not always match with high yield, the surplus of water can be used effectively and efficiently to produce various crops. The amount of irrigation water used could substantially be reduced by the application of compost. The target environments are lowland areas with water shortage and favorable upland with access to increase soil available water capacity. The objective of this study was to assess the number of irrigation applications and water savings through the optimum rate of compost application. Results show that in both tropical humid and semi-arid regions, compost application on some "thirstiest" and cash crops is a reliable means for water savings. The net irrigation depths substantially raised from the soil treated with chemical fertilizers to the compost treatments and as a consequence, reduced the number of irrigation applications by 16-12% in amended-soil. The difference in the number of irrigation applications ranged from 1 to 2 and 1 to 5 applications in tropical humid and semi-arid regions, respectively. With rainfall, supplemental irrigation was only necessary for rice and onion in tropical humid regions, while in semi-arid regions, irrigation constituted the main source of crop water supply. The potential water saved was estimated at 154.74, 5.40% and 34.94, 14.53% of the irrigation water need with and without rainfall in tropical humid and semi-arid regions, respectively and accounted for about 1.62% in average of the total Lake-Chad annual inflow. The amount of water saved could be used to double the growing areas of some cash crops and to recharge the underground water for water resource conservation and environmental restoration, supply to Lake-Chad or allocate to other water use sectors.

Key words: Compost · potential water saving · tropical humid · semi-arid regions · environment restoration

INTRODUCTION

Water saving technology should not only interest the arid and semi-arid regions, but also the tropical humid areas because of the uneven distribution of precipitation. Kuo *et al*. [1] in assessing the crop water requirements in the Taiwan ChiaNan irrigation district, emphasized that the unevenly distribution of rainfall is not always optimal for the growing seasons of various crops. Although water saving does not always match with high yield, the surplus water could be effectively and efficiently used to produce various other crops. Bouman and Tuong [2] suggested that paddy rice irrigation water input can be reduced and water productivity increased by introducing periods of nonsubmerged conditions of several days throughout the growing season. In subtropical area of China, systems of alternate submergence-nonsubmergence on rice production have been reported to maintain or even increase yield [3]. However, experimental evidence is still scarcely reported in the literature and the hydrological and environmental conditions under which these systems were practiced are not well known [4]. In lowland field and irrigated upland crops, the irrigation water use could substantially be reduced by

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the application of compost. The target environments are irrigated lowland with water shortage and favorable upland with access to increase soil available water capacity. In practice, irrigation can be applied to bring the soil water capacity up to field capacity once a lower threshold has been reached. For upland crops such as wheat and maize, this threshold is usually the soil water content halfway between field capacity and wilting point [5], but for upland rice, the optimum threshold for re-irrigation still needs to be determined [4]. This water content between field capacity and wilting point is defined as the available water capacity. Many dairy farmers apply organic manure predominately for fertilizing the soil and manure application could improve the soil properties, thereby improving the N balance. Organic manure has been found to be a reliable index of crop productivity in semi-arid regions because it positively affects soil water holding capacity [6, 7]. The beneficial effect of compost on crop growth is well known, however, there has been no report emphasizing its effect on crop irrigation water savings. Therefore, study on compost application on clay soil in both humid and semi-arid regions and its effect on irrigation water savings could contribute not only to lower the irrigation water inputs, but also to regenerate the already degraded environment. The objective of this study was to assess the number of irrigation applications and potential water saving through the optimum rate of compost application.

MATERIALS AND METHODS

Climate data: The reference evapotranspiration (ET_0), crop evapotranspiration (ET_{crop}) and Effective Rainfall (ER) were determined by computing 15-year average climate data from National Pingtung University of Science and Technology (NPUST) and Central Weather Bureau (CWB) of Taiwan located at 22° 39'N and 120°36'E and the meteorological station of NDjamena in the Republic of Chad situated at 15°00'N and 19°00'E, respectively, using the CROPWAT software [8]. The monthly mean maximum and minimum temperatures varied from 25.1°C in January to 33.2°C in July and 14.2°C in January to 24.2°C in July, respectively in Taiwan while it ranges from 32.2°C in January to 38.1°C in June and 14.7°C in January to 26.7°C in May, respectively in the Republic of Chad. Moreover, the monthly relative humidity ranges from 77.5% in March to 85.0% in August and 20.0% in March to 78.0% in August in Taiwan and Chad, respectively. The monthly mean solar radiation varied from 10.9 MJ m^{-2} d^{-1} in December to 16.4 MJ m^{-2} d^{-1} in June and 20.1 MJ m^{-2} d^{-1} in December to 23.9 MJ m^{-2} d^{-1} in May in Taiwan and Chad, respectively, while the wind speed and sunshine varied from 98.0 km d^{-1} in November to 292.0 km d^{-1} in May and 3.4 h in May to 4.6 h in January in Taiwan and 224.6 km d^{-1} in August to 449.3 km d^{-1} in March and 7.0 h in July to 10.1 h in December in Chad.

As a consequence the reference evapotranspiration ranges from 2.3 mm d^{-1} in December to 4.4 mm d^{-1} in April and 4.8 mm d^{-1} in August to 11.6 mm d^{-1} in February in Taiwan and Chad, respectively. The effective rainfall on the other hand ranges from 15.1 mm $month^{-1}$ in December to 188.9 mm $month^{-1}$ in August and 0.0 mm $month^{-1}$ in January, February, March and December to 132.7 mm $month^{-1}$ in August in Taiwan and Chad, respectively (Table 1).

Soil texture and available water capacity: The simplified hydrometer method described in the Particles Size Distribution [9] was used to determine the texture of four types of soil (3 from Taiwan and 1 from Chad). The textures of the soils were clay, sandy-loam and loamy-sand in Taiwan and clay in Chad with the specific gravity and available water capacity plotted in Table 2.

The virgin and compost mixed with sandy-loam and loamy-sand soils exhibited low available water capacity (Table 2 and Fig. 1). The target is to save water in lowland area, therefore, the Taiwan and Chad clay soils with high available water capacity were selected to investigate water saving. Clay soils were mixed with chemical fertilizer N-P-K (120:70:70) kg ha^{-1} as a control (usually utilized by Taiwanese farmers) and compost 5, 10, 5, 20, 30, 45 t ha^{-1}. The mean specific gravities (dry weight basis) and corresponding Available Water Capacity (AWC) are showed in Table 3.

The net irrigation depths (d) were determined using the soils available water capacity, the specific gravity and the root depth, defined as:

$$d(mm) = \alpha(AWC * As * D) \, [10] \qquad (1)$$

Where AWC is the available water capacity (%) [11];

α = 1 for paddy rice, ¾ for medium rooting cropping and ½ for shallow rooting cropping;

As is the soil specific gravity;

D: The root depth (mm).

The irrigation intervals (INT) and the number of irrigation applications (NIA) were calculated as followed:

Table 1: 15-year average evapotranspiration and effective rainfall of NPUST/CWB and NDjamena stations (1990-2004) month

	Taiwan (NPUST/CWB)			Chad (Ndjamena)		
	ET_0 (mm day^{-1})	Rainfall (mm $month^{-1}$)	ER[(a)] (mm $month^{-1}$)	ET_0 (mm day^{-1})	Rainfall (mm $month^{-1}$)	ER[(a)] (mm $month^{-1}$)
January	2.4	28.2	26.9	7.8	0.0	0.0
February	2.8	28.8	27.5	9.5	0.0	0.0
March	3.4	36.6	34.5	11.6	0.0	0.0
April	3.7	96.4	81.5	10.9	8.4	8.3
May	4.4	244.9	148.9	10.1	28.5	27.2
June	4.1	389.0	163.9	8.2	49.8	45.8
July	4.0	464.9	171.5	6.4	171.6	124.5
August	3.7	639.3	188.9	4.8	191.1	132.7
September	3.4	326.5	157.6	5.5	99.7	83.8
October	3.0	81.1	70.6	6.9	31.3	29.7
November	2.6	15.6	15.2	8.4	2.6	2.6
December	2.3	15.5	15.1	7.7	0.0	0.0
Total (mm $year^{-1}$)	3.3	2366.8	1102.1	8.1	583.0	454.6

[(a)]Effective rainfall calculated using the United States Soil Conservation Service (USSCS) formulas: Effective R. = (125-0.2 * Total R.)* Total R./125... (Total R.<250 mm/month), Effective R. = 0.1 * Total R.-125 (Total R. > 250 mm/month)

Table 2: Texture of soils used for determining the effect of compost application on soil available water capacity (weight basis)

Soil code	Sand (%)	Clay (%)	Silt (%)	Specificgravity	AWC (%)	Textural class
TCS	26.83^{c*}	46.28^{b}	26.89^{a}	1.30^{d}	26.2^{a}	Clay
TSLS	62.30^{b}	14.67^{c}	23.30^{a}	1.40^{c}	24.9^{c}	Sandy loam
TLSS	76.19^{a}	7.65^{d}	16.16^{b}	1.45^{b}	17.5^{d}	Loamy sand
CCS	22.47^{c}	60.11^{a}	17.42^{b}	1.55^{a}	25.3^{b}	Clay

*Means with the same letter within column are not significantly different at 5% level (Duncan MRT). TCS: Taiwan clay soil, TLSS: Taiwan loamy-sand soil, TSLS: Taiwan sandy-loam soil, CCS: Chad clay soil

Table 3: Specific gravity and available capacity of some amended Taiwan and Chad clay soils

	Taiwan		Chad	
Treatments	Specific gravity	AWC (%)	Specific gravity	AWC (%)
120:70:70	1.30	25.80	1.51	25.00
C5*	1.28	27.50	1.51	26.50
C10	1.27	28.40	1.50	27.40
C15	1.26	28.00	1.49	27.20
C20	1.24	28.50	1.48	25.40
C30	1.22	28.20	1.47	26.00
C45	1.20	27.20	1.46	25.00

* C5, C10, C15, C20, C30, C45 Compost 5, 10, 15, 20, 30 and 45 t ha^{-1} treatments

$$INT = \frac{d}{(ETcrop - ER)} GD \tag{2}$$

Where; (d) is the net irrigation depth (mm); ER is the seasonal effective rainfall (mm); ET_{crop} is the crop water need (mm); GD is the crop growth duration (days); and the number of irrigation applications (NIA):

$$NIA = \frac{GD}{INT} \tag{3}$$

Rice, sugarcane, wheat, three "thirstiest" crops [12] and tomato, onion, cabbage, the most irrigated cash crops were selected for this study in tropical humid (Taiwan) and semi-arid (Chad), two different climatic regions.

Crops coefficients were monthly determined from that of different growth stages defined by Doorenbos and Pruitt [5]. Analysis of variances and graphs were carried out using SAS V.8 and SigmaPlot 2001 softwares.

RESULTS AND DISCUSSION

Effect of compost application on the soil available water capacity: The available water capacity of Taiwan and Chad clay soils was estimated based on the compost application (Fig. 1) and reflected about 91% and 78% the variation of compost application (Eq. 4 and 5).

The available water capacity increased to reach the maximum and then declined; hence there exists a point at

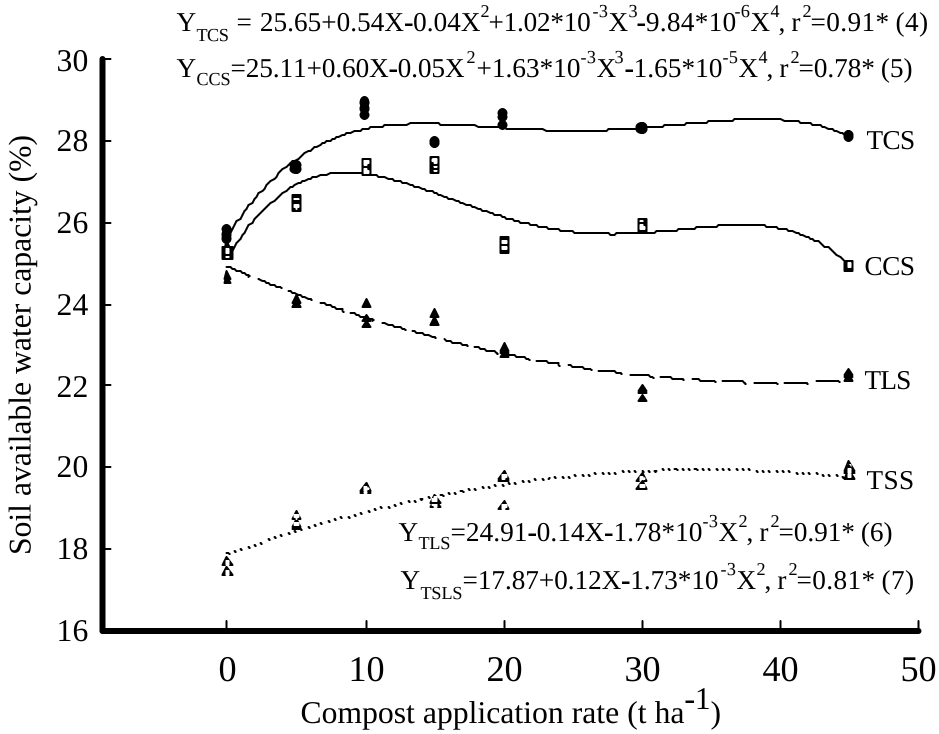

Fig. 1: Soil available water capacity in response to compost application on Taiwan and Chad soils

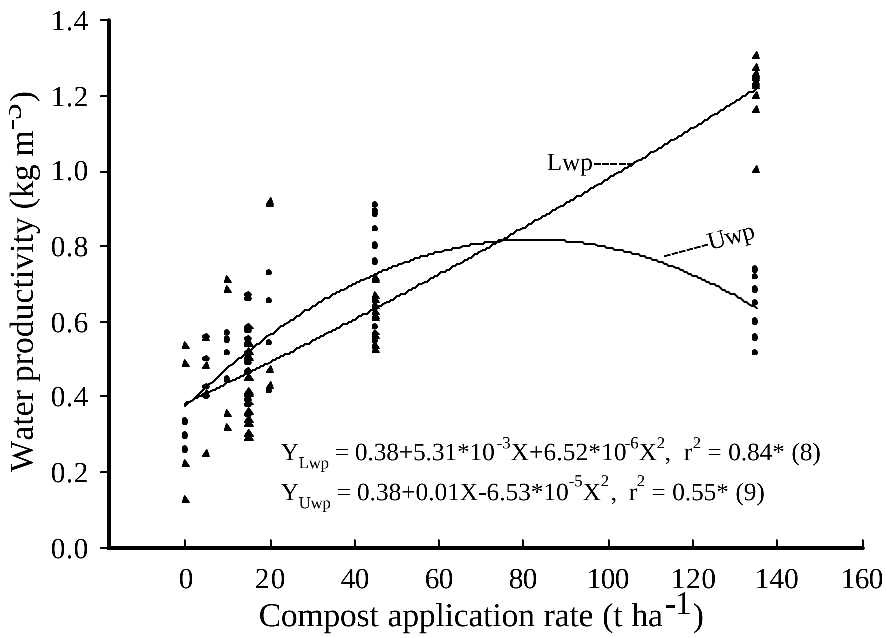

Fig. 2: Water productivity in response to compost application on clayey soils

Table 4: Monthly crop coefficients (K_c)

	Months												
Crops	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
Rice1*							1.10	1.10	1.15	1.05	1.00		
Rice2		1.10	1.10	1.25	1.00								
Wheat						0.35	0.75	1.15	0.45				
Sugarcane		0.45	0.60	0.85	1.00	1.20	1.30	1.30	1.30	1.30	1.05	0.75	
Tomato		0.45	0.70	0.95	1.15	0.85							
Onion				0.65	0.95	1.05	1.00	0.85					
Cabbage									0.45	0.70	0.75	1.05	0.90

*1 and 2: Fall and spring rice

Table 5: Crop evapotranspiration (mm) and effective rainfall (mm) in the growth period

	Growth*		Taiwan (NPUST/CWB) stations		Chad (NDjamena) station	
Crops	Period	Duration	ET_{Crop}	ER	ET_{Crop}	ER
Rice1	Aug-Dec	130	918.70	447.50	1440.40	248.80
Rice2	Feb-May	120	952.90	292.40	1886.80	35.50
Wheat	June-Sept	120	303.60	681.60	469.30	386.80
Sugarcane	Feb-Dec	320	1112.40	1102.10	2452.80	454.60
Tomato	Feb-June	150	467.90	754.70	774.30	338.50
Onion	Apr-Aug	150	536.20	456.30	1071.70	81.30
Cabbage	Sept-Jan	120	264.00	285.40	816.52	116.10

*Data from FAO paper No. 24 [5], ER: Effective Rainfall, 1 and 2 fall and spring rice

which the derivative of those functions equals to zero. The optimum compost application rates and the corresponding available water capacity at those maxima were determined at 10.21 t ha^{-1}, 28.0% and 10.64 t ha^{-1}, 27.5% respectively, using the trial error Newton method. The values were used to assess the level of water productivity and the crop net irrigation depth. From the above figure, the compost application on clay soil significantly improved the available water capacity.

Water productivity as affected by the application of compost: Rice productivity was determined from the data of two growing season-experiments in a control green house conditions. *Oriza Sativa* L. variety Taichung No.10 was grown under lowland conditions using chemical fertilizer N-P-K (120:70:70) kg ha^{-1} and 5, 10, 15, 20, 45 and 135 t ha^{-1} of compost. The water productivity obtained in those treatments ranges from 0.38 to 1.22 kg m^{-3} and 0.38 to 0.70 kg m^{-3} under lowland and upland conditions, respectively.

The change in water productivity reflected about 84% and 55% the variation of compost application in lowland and upland crops respectively as defined in the equations (8) and (9) in Fig. 2.

From the compost application vs. water productivity equations, it can be observed that water productivity were 0.43 and 0.48 kg m^{-3} and 0.44 and 0.48 kg m^{-3} under lowland and upland conditions using the optimum compost rates (10.21 t ha^{-1} and 10.64 t ha^{-1}) in Taiwan and Chad, respectively. The values of water productivity obtained through the equations were in the range reported by some previous studies. The rice water productivity in 1995 ranged from 0.15 to 0.60 kg m^{-3} and the sustainable increases in water productivity can only be achieved through integrated farm-resources management [13, 14]. Tuong and Bouman [15] summarized a range of water productivity from 0.4 to 1.1 kg m^{-3} for rice in farmer fields and irrigation systems of Northwest India, therefore the subsequent values of available water capacity generated by the optimum compost rates can be efficiently used in accessing crop water need.

Irrigation water need: The long-term meteorological data from 1990 to 2004 of the NPUST-CWB in Taiwan and Ndjamena-Chad meteorological stations were used to calculate the reference evapotranspiration. The crop water need was calculated on a monthly basis using:

$$ET_{crop} = ET_0 * K_c \quad [10]$$

Where; ET_{crop}: is the crop evapotranspiration, ET_0: the reference evapotranspiration, K_c is the crop coefficients.

Table 6: Net irrigation depths, irrigation intervals, number of irrigation applications and irrigation water saving determined on chemical fertilizer and compost treatments in Taiwan and Chad

		Soil amended with chemical fertilizer			Soil amended with compost			Water savings
Regions	Crops	d (mm)	INT (days)	NIA (No.)	d (mm)	INT (days)	NIA (No.)	(mm)
Taiwan	Rice1	134	18	8	142	20	7	142
(Pingtung)	Rice2	134	16	8	142	17	7	142
	Wheat	100	39	4	107	42	3	107
	Sugarcane	150	43	8	160	46	7	160
	Tomato	67	21	8	71	22	7	71
	Onion	33	9	17	36	10	15	72
	Cabbage	33	15	8	36	16	7	36
Chad	Rice1	151	13	10	165	14	9	165
(NDjamena)	Rice2	151	9	14	165	10	12	330
	Wheat	113	28	5	124	31	4	124
	Sugarcane	170	22	15	186	24	14	186
	Tomato	76	14	11	83	15	10	83
	Onion	38	5	30	41	6	25	205
	Cabbage	38	5	24	41	6	20	164

The crop coefficient K_c (Table 4) based on the growth stages [16] were calculated on a monthly basis. The Table 5 shows the crop water need, growth duration and the effective rainfall during the growth of crops. The crop water need during the growth period varied from 264.0 mm on cabbage to 1112.4 mm on sugarcane in Taiwan, while it ranges from 469.3 mm on wheat to 2452.8 mm on sugarcane in Chad. For lowland rice, the water for soil saturation (200 mm), percolation (180 mm month^{-1}) and water layer (100 mm) [5] were added to the crop evapotranspiration. The difference of water need between those two regions was attributed to the higher evapotranspiration observed in NDjamena station. The effective rainfall varied from 285.4 mm in the period where the cabbage was grown to 1102.1 mm on sugarcane in Taiwan and 35.5 mm on rice (Feb-May) to 454.6 mm on sugarcane (Feb-Dec) in Chad. The large difference between precipitation and ET_{crop} means that irrigation water resources are the most important limiting factor for sustainable crop production in this area.

The irrigation water need of rice and sugarcane were similar to the one obtained by Kuo *et al.* [1]. In the Republic of Chad, irrigation water need was higher for rice, wheat, sugarcane, tomato, onion and cabbage, respectively (Table 5). Those data were in the ranges given by the Rural Development Integrated Project of Chari-Logone Basin (Chad-Cameroon) in the feasibility study [17] and FAO No. 24 [5].

Irrigation water depth, number of irrigation applications and water saving: The rooting depths of rice, wheat and tomato were estimated at 40 cm that of sugarcane, onion and cabbage at 60 cm and 20 cm respectively. Table 6 shows the net irrigation depths, the irrigation intervals and the number of irrigation applications in chemical fertilizer and the optimum compost treatments. The net irrigation depths were 33 mm on cabbage and onion, 67 mm on tomato, 100 mm on wheat, 150 mm on sugarcane and 134 mm on rice in Taiwan while it was 38, 76, 113, 170 and 151 mm in chemical fertilizer treatments in Chad. In compost treatments, the net irrigation depths were 36, 71, 107, 160 and 142 mm in Taiwan and 41, 83, 124, 186 and 165 mm in the Chad clay soil. Irrigation intervals on the other hand, varied from 9 days on onion to 43 days on sugarcane in Taiwan and 5 days on onion to 28 days on wheat in Chad in the chemical fertilizer treatments. In the compost treatments, they range from 10 days on onion to 46 days on sugarcane in Taiwan and 6 days on onion to 31 days on wheat in Chad. Consequently, the number of irrigation applications was substantially low in both tropical humid and semi-arid regions. The difference in the number of irrigation applications varied from 1 to 2 and 1 to 5 applications in Taiwan and Chad, respectively As a result, the water savings during the growing period ranges from 36 to 160 mm in Taiwan and 83 to 330 mm in Chad.

Considering the contribution of the rainfall during the growing period, wheat, sugarcane, tomato and cabbage do not need any irrigation in Taiwan, while supplemental irrigation ranged from 1 to 25 applications were necessary for completing plant growth in Chad under amended soil. Nevertheless, potential huge

Table 7: Irrigation intervals, number of irrigation applications and irrigation water saving determination taking into account the amount of precipitation during the growing period in Taiwan and Chad

Region	Crop	Supplemental irrigation water need (mm)	Soil amended with compost under rainfall d (mm)	INT (days)	NIA (No.)	Water savings in compost compared to that of chemical fertilizer treatments (mm)
Taiwan (Pingtung)	Rice1	471.21	142	39	4	568
	Rice2	660.46	142	25	5	426
	Wheat	-378.04	107	0	0	428
	Sugarcane	10.32	160	0	0	1280
	Tomato	-286.77	71	0	0	568
	Onion	79.86	36	66	3	504
	Cabbage	-21.38	36	0	0	288
Chad (NDjamena)	Rice1	1191.59	165	18	8	330
	Rice2	1851.34	165	10	12	330
	Wheat	82.54	124	179	1	496
	Sugarcane	1998.16	186	29	11	744
	Tomato	692.95	83	28	6	415
	Onion	733.16	41	6	25	205
	Cabbage	700.42	41	7	18	246

No irrigation is needed showing by the excess of the amount of rainfall indicated with (-)

Table 8: Amended soil water saving in fall and spring cropping seasons in Taiwan and Chad

			Without rainfall			With rainfall	
Regions	Crops	Area (ha)	Irrigation water need ($10^6 m^3$)	Water saved (10^6 m^3)	Percent water saved (%)	Water saved (10^6 m^3)	Percent water saved (%)
Taiwan	Rice1	135314	1243.14	192.15	15.46	768.58	61.83
	Rice2	161700	1540.77	229.61	14.90	688.84	44.71
	Wheat	12343	37.47	13.21	35.25	52.83	140.99
	Sugarcane	777	8.64	1.24	14.39	9.95	115.11
	Tomato	5043	23.60	3.58	15.17	28.64	121.37
	Onion	834	4.47	0.60	13.43	4.20	94.03
	Cabbage	8084	21.34	2.91	13.64	23.28	109.10
	Total	324095	2879.43	443.30	15.40	1576.33	54.74
Chad	Rice1	5500	79.22	9.08	11.46	18.15	22.91
	Rice2	4500	84.91	14.85	17.49	14.85	17.49
	Wheat	9000	42.24	11.16	26.42	44.64	105.68
	Sugarcane	3754	92.08	6.98	7.58	27.93	30.33
	Tomato	2000	15.49	1.66	10.72	8.30	53.58
	Onion	2000	21.43	4.10	19.13	4.10	19.13
	Cabbage	2000	16.33	3.28	20.09	4.92	30.13
	Total	28754	351.70	51.11	14.53	122.89	34.94

amounts of water were saved compared to the water use in chemical fertilizer treatments without rainfall. They varied from 288 to 1280 mm in Taiwan and 205 to 744 mm in Chad (Table 7). The supplemental irrigation observed in all crops in the Republic of Chad indicated that the irrigation was the main source of crop water supply in the scarce precipitation regions.

Irrigation water saved in tropical humid (Taiwan) and semi-arid (Chad) regions: a simulated case study: In the Republic of Chad, the agricultural sector is the largest water consumer [18]. Out of the total of 30273 ha of the irrigated crop areas, 3754 ha of sugarcane are irrigated by sprinklers and the remaining 26519 ha by gravity. The main "thirstiest" crops (rice, wheat, sugarcane) and cash crops (tomato, onion, cabbage) irrigated areas are shown in Table 8. There are 10000, 9000, 3754 ha of rice, wheat and sugarcane, respectively and 2000 ha for each cash crop including tomato, onion and cabbage. A total of 28754 ha were irrigated with irrigation water need of about $351.70*10^6$ m^3, ranging from $15.49*10^6$ m^3 on tomato to $92.08*10^6$ m^3 on sugarcane. Total water savings were estimated at about 51.11*10^6 m^3 representing 14.53% of the total water need in the conditions without rainfall. Including rainfall, the total water saved was 122.89*10^6 m^3 or 34.94% of the total water consumption. In both tropical humid and semi-arid regions, the use of compost on the "thirstiest" as well as on cash crops is a reliable means for water saving. These amounts of water saved can be used to double the area of wheat, tomato, onion and cabbage, to recharge the underground water, or to supply Lake-Chad as suggested by Odada *et al.* [19] who stipulated that, due to the lowering level or drying of the Lake Chad and of the reduced inflows of its main rivers, every new irrigation development must be studied very carefully for a sustainable agriculture. Extended to the whole Lake-Chad Basin Commission actually irrigated area estimated at about 115,000 ha [19], potential water saving using the compost application technology contributed in average to about 1.62% of the total annual water inflow (43 km^3 $year^{-1}$) of lake-Chad [18]; this technology could substantially contribute to the restoration of the environment by recharging Lake-Chad.

In Taiwan, the tropical humid area, a total of 324095 ha of those selected crops were irrigated in 2004 [20] with a total water need of 2879.43*10^6 m^3. The potential annual water saving using this new technology was estimated at about 443.30*10^6 m^3, which represents 15.40% of the total water need without rainfall. Including rainfall, the irrigation water saving was about 1576.33*10^6 m^3 or 54.74% of the total water need.

Individual potential water savings over 100% could be explained as the improvement of the available water capacity under the effect of compost application. This amount of water saved can be used in agriculture to supplement the deficit irrigation caused by the unevenly rainfall distribution in upland, or in the other water use sectors.

CONCLUSIONS

In both tropical humid and semi-arid regions, compost application on some "thirstiest" and cash crops, is a reliable means for water savings. The net irrigation depths substantially raised in the compost amended-soil compared to chemical fertilizer treatments and as a consequence, lowered the number of irrigation applications in compost treatments. The difference in the number of irrigation applications ranged from 1 application on cabbage to 2 applications on sugarcane and 1 to 5 applications on wheat and onion in tropical humid and semi-arid regions, respectively. With the contribution of rainfall, supplemental irrigation was only necessary for rice and cabbage in tropical humid region, while in semi-arid regions, irrigation constitutes the main source of crop water supply. The total water saving was estimated at 14.53, 34.94% and 15.40, 54.74% of the total irrigation water need without and with rainfall in tropical semi-arid and humid regions, respectively. The amount of water saved which represented 1.62% on average of the total Lake-Chad annual inflow, can be used to double the growing areas of some upland crops, to recharge the underground water for water resource conservation and environmental restoration or to supply to Lake-Chad. In tropical humid regions, this water saved could be used as a supplemental irrigation or allocate to the other water use sectors. In both tropical humid and semi-arid regions, the use of compost on "thirstiest" as well as on cash crops is a reliable means for water saving. Although water saving on sugarcane is as high as that of grain crops, the investigation of crop sugar content constitutes a precondition for final conclusion.

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