Assessment of Wind Erosion in Bare and Lucerne-cultivated lands in North Atbara, River Nile State, Sudan

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Abstract- The experiment was conducted in two-successive seasons (August 2008- March 2009, August 2009- March 2010). The intensity of wind erosion (IWE) was measured monthly in four directions, namely West (W), North West (NW), North (N), and North East (NE), using vertical (IWE_v) and horizontal soil traps(IWE_h) in a bare and a Lucerne-cultivated land. In the first season, IWE_h in the bare land ranged from183.3 (W) to 200 (NE) with a mean of 192.9 tons/ha/day, and a coefficient of variation (CV) of 4%. Furthermore, IWE_h ranged from 123.3 (Oct.) to 262 (Aug.) with a CV of 33.2%. The overall mean IWE_h and IWE_v in the first season were 1.3 and 1.4 fold those in the second season, respectively. In bare lands, the overall mean IWE_h was 1.77 and 1.88 fold the corresponding IWE_v values in the first and second seasons, respectively. In the cultivated fields the reverse trend was found in the first season, the overall mean of IWE_v yielded significantly much higher than that produced by IWE_h but in the second season result was inverse with very meager increasing in the overall mean value of IWE_h. The ratio IWE_v/ IWE_h of the overall mean values was 1.4 and 0.85 in the first and second seasons, respectively. The IWE_h in the bare lands were 47.0 and 45.7 fold that of the cultivated fields in the two successive seasons.

Index Terms- Intensity of wind erosion; sand traps; Lucerne-cultivated land; River Nile State.

I. INTRODUCTION

The River Nile State lies between latitudes 16° and 22° N and longitudes 31° 88′ and 35° 70′ E. It is dominated by hyper–arid and arid climatic zones with mainly two seasons, a hot summer from April to September and cold winter from October to March. The mean annual rainfall is less than 100 mm. and temperatures as high as 49^o C is not uncommon in the period extending from April to June. Winds prevail from the north east with a mean maximum speed of 17.6 km/hr. Under such climatic conditions wind erosion is the predominant desertification process.Wind erosion is governed by two main factors namely soil or wind erodibility as an indicator of the vulnerability of the soil mass to detachment by wind, and wind erosivity as an indicator of the ability of the wind energy to transport the detached soil particles. Generation of wind erosion data is essential for designing wind erosion control methods, particularly in arid lands. Previous wind erosion studies were undertaken included assessment of the intensity of wind erosion (IWE) in El-Obeid (Khairelseid, 1998) and north east Al-Butana (Haikal, 2005). Hassan and Mustafa (2011) assessed and mapped wind erodibility of the soils of fifty geo-referenced farms widely spread in the River Nile State. They found that wind erodibility of these farms ranged from 0 to 470.4 tons/ha. They found that these agricultural farms lie within the high erodibility class. Abdi *et al.* (2013) studied the impacts of desertification, degradation and drought on both the natural resources and man's livelihood in the Sudan and to suggest appropriate forest resource management interventions. Results showed that in rain-fed agricultural zones deep ploughing and leveling of the surface soil caused increases susceptibility of soil to wind erosion, beside decline in its fertility and in some places, enhance the formation of sand dunes. The implications of these trends on the natural resource base include environmental degradation, food insecurity and aggravation of income inequalities among the Sudanese producers. The study has suggested agroforestry technology as a potential solution to this continued problem of declining rural agricultural production in the Sudan. Dawelbait *et al.* (2013) identified changes in ground cover of endangered range plant species in north Kordofan state. They found changes in range attributes were clearly noticed and some important plants are being endangered so the study recommended a strategy for range land rehabilitation to be adopted in relation to composition of important, palatable endangered plant species. These studies are very important due to determination the trends of range land so as controlling degradation in plant and natural vegetation composition furthermore carrying capacity should be calculated to avoid the negative impact of overgrazing. Biro *et al*. (2013) analyzed and monitor the land use land cover (LULC) changes using multi-temporal Land sat data for the years 1979, 1989 and 1999 and ASTER data for the year 2009. In addition, efforts were made to discuss the impact of LULC changes on the selected soil properties. Three main LULC types were selected to investigate the properties of soil, namely, cultivated land, fallow land and woodland. Moreover, soil samples were also collected at two depths of surface soil from ten sample plots for each of the LULC type. For these soil samples, various soil properties such as texture, bulk density, organic matter, soil pH, electrical conductivity, sodium adsorption ratio, phosphorous and potassium were analyzed. The results showed that a significant and extensive change of LULC patterns has occurred in the last three decades in the study area. Further, laboratory tests revealed that soil properties were significantly affected by these LULC changes. The change of the physical and chemical properties of the soil may have attributed to the changes in the LULC resulting in land degradation, which in turn has led to a decline in soil productivity. Adam *et al.* (2014) assessed land degradation in Rawashda, area Gedaref state by using remote sensing, GIS and soil techniques. Ali *et al*. (2012) assessed and mapped of soil degradation at Gadambalyia schemes in Gedaref state, related to sorghum productivity. Satellite images and GIS were integrated with soil quality to detect and map the type and degree of severity of soil degradation. Soil quality indicators were determined and compared with the same indicators, determined previously in the same locations in 1976. The System Integration Risk model was used to classify the area of schemes according to soil chemical and physical degradation. The results revealed that the soil qualities in 2005 were significantly affected ($P< 0.001$) both negatively and positively, compared with the 1976 data. Soil chemical degradation ranged from low to severe, while the soil physical properties were not significant degraded. The long term average of the sorghum for all farms was between 1 to 3.5 sac per feddan (1 sac =100 kg; 1 feddan = 0.42 ha). About 1.5% of the total farms (262 farms) had long term average less than 1.5 sacs per feddan. 44.3% of the farms had long term average of 2.5 sacs feddan $^{-1}$, and 34% of the farms had long term average of 3 sacs fed^{-1} and above. Only about 10% of the total area had no yield deterioration while about 57% had low to moderate yield deterioration and 33% had high to severe degradation. This means that, although the soil was highly degraded, it was still possible to obtain some sorghum. Abuzied *et al.* (2015) they assessed the extent of sand movement by saltation and surface creep in central part of the Northern state for three areas, namely Al-Baja, west of Al-Golied town and Al-Khowie using soil trenches. In the first season, the rate of sand movement in all months, excepting July in El-Khowi was significantly ($P < 0.001$) higher than that in Al- Golied. In July the rates were equal. The overall mean monthly rate at El-Khowi was 1.39 m^3/m-w, which was more than 4-fold that in Al- Golied (0.32 m^3/m-w). In the second season, the mean monthly rate was 1.69m^3/m-w at El-Khowi, which was 3.8-fold, that of Al- Golied (0.44m^3/m-w) and 5.3-fold that of Al-Baja (0.32m^3/m-w). The lowest sand drift at Al-Baja site was attributed to the fact that Al-Baja land form is a sand sheet plain. The higher sand movement in the second season was due to the higher wind erosivity in that season as indicated by sand storm visibility ≤ 1 km. The present study was undertaken to achieve the following objectives

1. To generate comprehensive quantitative data on IWE in bare and Lucerne-cultivated lands in north Atbara, River Nile State, using both horizontal and vertical traps.
2. To investigate direction and monthly variation of the IWE.
3. To compare the intensity of wind erosion measured by horizontal (IWE_h) and vertical traps (IWE_v).

II. MATERILS AND METHODS

2.1. EXPERMINT MATERIALS

The study was conducted in Aboharaz village, about 36 km north Atbara town on the western bank of the River Nile, to produce broad–base data on wind erosion in two-seasons (August 2008-March 2009, August 2009-March 2010). Two fields, 2 km apart, were used for the study, one was bare and the other was cultivated with Lucerne (*Medicago sativa*).

2.2.METHODS AND STATISTICAL ANALYSIS

Oil cans [25 cm (L) × 23 cm (w) x 27 cm (h)] were used as horizontal sand traps for the measurement of wind erosion. They were buried in the soil leaving the open end level with the soil surface. A vertical sand trap was constructed locally as described by Leatherman (1978). It consisted of two PVC tubes. The first one was 60 cm long with an inside diameter (i.d.) equal to 5.1 cm, permanently closed at the bottom end, and inserted completely in the soil with its open end leveled with the soil surface. This tube is stationary. The second tube, 90 cm long and 4 cm i.d., closed at the bottom with a moveable metallic cap, and had two similar slits 2 cm wide and 30 cm long cut in the two opposite sides of the tube. One slit serviced as a collection orifice aligned toward the wind direction, while the other was covered with fine metallic screen to restrict soil particle movement and allow free wind flow. In each field, IWE (ton/ ha/day) was assessed using three replicates for both vertical and horizontal traps in the following directions: West (W), North West (NW), North (N) and North east (NE). Vertical traps were installed at a spacing of 60 cm between the same direction and 1 m from another direction. The replicate traps were installed so that they do not obstruct free wind flow to the other traps. The horizontal traps were placed at a spacing of one meter from the vertical. Each month the horizontal traps were removed and sand was collected and weighed. Furthermore, the sand collected in the metallic moveable tube of the vertical traps was also weighed. These monthly IWE were determined for each direction during the two seasons. The statistical design for this factorial experiment was randomized complete block design. Analysis of variance and separation of means were undertaken according to Gomez and Gomez (1984).

III. RESUL AND DISCUSSION

3.1. FIRST SEASON (August 2008-March 2009)

Table 1 shows the effects of wind direction and month on IWE_h of the bare field. For the main direction effect the mean IWE_h ranged from 183.3 (W) to 200 (NE) with a mean of 192.9 tons/ha/day, a standard deviation (STD) of 8.0 tons/ha/day and a coefficient of variation (CV) of 4%. The mean IWE_h by the NE wind was significantly greater than that produced by the W direction. However, it was not significantly different from that given by N wind, which was also significantly different from that produced by W winds.

The mean IWE_h values for the main month effect ranged from 123.3 (Oct.) to 262 (Aug.) with a mean of 192.9 tons/ha/day, a STD of 64 tons/ha/day and a CV of 33.2%. Statistically, IWE_h was in the following significant order: Aug. > Jan.> Feb. > Mar. > Nov. > Dec. > Sept. > Oct.; the equal sign indicates that there was no significant effect.

Table 1 Effect of direction and month on the IWE$_h$ (ton ha^{-1} day^{-1}) measured in the bare field surface during the first season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	261	126.0	119.0	134.3	120.0	242	238	226.1	183.3b
NW	260	126.0	127.0	153.0	129.4	259	238	220.3	189.1b
N	263	130.4	118.0	165.0	133.3	267	267	246.4	199.0a
NE	264	126.0	129.3	179.1	133.3	267	261	241.0	200.0a
Mean	262a	127.1e	123.3e	158d	129e	258.8ab	251b	233.5c	192.9

*Means followed by the same letter in the same row or column are not significantly different from each other at the 0.01 level by Duncan Multiple Range Test

Table 2 shows the effects of wind direction and month on IWE$_v$ of the bare field. The mean IWE$_v$ values ranged from 70 (W) to 127 (NW) with a mean of 108.8 tons/ha/day, a STD of 26 tons/ha/day and a CV of 24%. Despite of the high mean IWE$_v$ value caused by the NW wind was not significantly to that produced by winds from the three other directions. The mean monthly data ranged from 65.3 (Sept.) to 156.1 (Jan.) with a mean of 108.8 tons/ha/day, a STD of 35 tons/ha/day and a CV of 32.2%. The monthly IWE$_v$ values were in the following statistically significant order: Jan. > Mar. > Feb.>Aug.>Nov.>Oct.>Dec. >Sept. The IWE$_v$ values obtained for each month or direction were lower than the corresponding IWE$_h$ values. The overall mean IWE$_v$ value was 56.3% that of IWE$_h$.

Table 2 Effect of direction and month on the IWE$_v$ (ton ha^{-1} day^{-1}) measured in the bare field surface during the first season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	111.1	64.0	82.0	75.0	28.4	57.0	56	83.3	70.0a
NW	118.0	71.1	81.0	103.0	102.0	204.0	167	167.0	127.0a
N	116.0	63.0	82.2	101.1	79.4	159.4	165	167.0	117.0a
NE	111.1	63.0	78.3	78.0	102.0	204.0	167	166.1	121.2a
Mean	114.1ab	65.3b	81ab	89.3ab	78ab	156.1a	139ab	146ab	108.8

*Letters as explained in Table1.

Table 3 shows that in the cultivated field, IWE$_h$ data for the main direction effect ranged from 2.3 (NW) to 6.1 (W), with a mean of 4.1 tons/ ha/ day, a STD of 1.6 tons/ ha/ day and a CV of 39%. As expected the data generated in this cultivated field were much lower than the corresponding data obtained from the bare field. The overall mean of IWE$_h$ of this field is about 2.1% of that of the bare field. The mean IWE$_h$ value produced by the W wind was significantly greater than that produced by NW and NE winds, but it was not significantly different from that produced by N winds. The table also shows that the monthly IWE$_h$ data ranged between 2.4 (Jan., Feb, Mar.) and 8.3 (Nov.), with a mean of 4.1 tons/ ha/ day, a STD of 2.1 tons /ha/ day and a CV of 51%. The main monthly effect showed that IWE$_h$ was in the following significant order: Mar. > Nov.>Aug.>Sept > Oct.> Dec.> Jan. = Feb.

Table 4 shows that the IWE$_v$ data for the main direction effect, in the cultivated field ranged from 0.41 (NE) to 18.3 (W), with a mean of 5.8 tons/ ha/ day, a STD of 8.4 tons/ ha/ day and a CV of 144.8%. The overall mean IWE$_v$ of this field is about 5.3% that of the corresponding bare field. The main wind direction effect showed that IWE$_v$ was in the following significant order: W > NW = N =NE. The table also shows that the monthly IWE$_v$ data ranged between 1.5 (Sept.) and 10.3 (Nov.), with a mean of 5.8 tons/ ha/ day, a STD of 3.3 tons/ ha /day and a CV of 56.9%. The main monthly effect showed that IWE$_v$ was in the following significant order: Nov.> Dec.> Jan.> Feb. = Mar.> Aug.> Oct.> Sept.

Table 3 Effect of direction and month on the IWE$_h$ (ton ha^{-1} day^{-1}) measured in the cultivated field during the first season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	10.3	5.7	5.9	11	5.00	3.7	3.6	3.6	6.1a
NW	2.9	1.4	1.7	4	2.10	2.1	2.1	2.1	2.3b
N	7.5	5.7	6.4	12	0.58	1.4	1.4	1.4	4.5ab
NE	2.5	4.9	2.7	6	3.00	2.4	2.4	2.4	3.3b
Mean	5.8ab	4.4b	4.2b	8.3a	2.70b	2.4b	2.4b	2.4b	4.1

*Letters as explained in Table 1

Table 4 Effect of direction and month on the IWE$_v$ (ton ha^{-1} day^{-1}) measured in the cultivated field during the first season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	

W	3.3	2.0	5.0	33.2	26.0	26.0	25.5	25.5	18.3a
NW	4.1	2.4	2.3	5.2	3.0	3.0	3.0	3.0	3.3b
N	2.0	1.3	1.0	2.0	0.8	0.8	0.8	0.8	1.2b
NE	0.8	0.4	0.4	0.87	0.2	0.2	0.2	0.2	0.41b
Mean	2.6bc	1.5c	2.2bc	10.3a	8abc	7.5abc	7.40abc	7.40ab	5.8

*Letters as explained in Table 1

3.1. SECOND SEASON (August 2009-March 2010)

In the bare land, the mean IWE_h values for the main direction effect ranged from 130.5 (W) to 162.1 (N) with a mean of 150.7 tons/ ha/ day, a STD of 14.3 tons/ ha/ day and a CV of 9.5% (Table 5). The main wind direction effect showed that IWE_h was in the following significant order: N > NW = NE =W. The mean IWE_h values for the main month effect ranged from 29 (Oct.) to 254.5 (Jan.) with mean of 150.7 tons/ ha/ day, a STD of 84.5 tons/ ha day and a CV of 56.1%. The monthly main effect was in the following significant order: Jan. > Feb.> Mar.> Aug.> Sept.> Dec.> Nov.> Oct. The IWE_h in the bare field surface in the second season was much lower than that in the first season. The overall mean IWE_h value in the second season was 78.1% of that in the first season. There was also variation in the order of magnitude of mean values in the corresponding months or directions.

Table 5 Effect of direction and month on the IWE_h (ton ha^{-1} day^{-1}) measured in the bare field surface during the second season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	121.9	117.8	18.4	48.1	43.5	233.5	236.3	224.1	130.5c
NW	125.9	124.6	29.0	89.9	124.6	256.9	235.6	218.3	150.6b
N	129.0	118.6	32.9	108.9	126.4	263.8	268.5	248.6	162.1a
NE	128.1	125.6	35.8	106.1	114.8	263.8	260.7	241.6	159.6b
Mean	126.2c	121.7c	29.0f	88.3e	102.3d	254.5a	250.3a	233.2b	150.7

*Letters as shown in Table 1.

Table 6 shows that the mean IWE_v values for the main direction effect in the bare land ranged from 49.5 (W) to 96.6 (NW) with a mean of 80.3 tons/ ha/ day, a STD of 21 tons/ ha/ day and a CV of 26.2%. The mean IWE_V produced by NW winds was significantly greater than that produced by W winds, but not different from that blown by N and NE winds. The monthly IWE_v data ranged from 9.1 (Oct.) to 151.7 (Jan.) with a mean of 80.3 tons/ ha/ day, a STD of 56.6 tons/ ha/ day and a CV of 70.5%. The main effect of the month showed that IWE_v was in the following significant order: Jan.> Mar.> Feb.> Sept.> Aug.> Dec.> Nov.> Oct. The overall mean IWE_v of the second season was 73.8% of that in the first season. There was also variation in the order of magnitude of monthly IWE_v values or those of the wind directions. As expected the mean IWE_v values obtained for each month or direction were lower than the corresponding IWE_h values.

Table 7 shows that the IWE_h data in the cultivated field ranged between 1.7 (NW) and 4.4 (N), with a mean of 3.3 tons/ ha/ day, a STD of 1.2 tons/ ha/ day and a CV of 36.4%. The overall mean IWE_h of this field is about 2.2% of that of the bare field in the second season. The main wind direction effect showed that IWE_h was in the following significant order: N = W > NE > NW. The table also shows that the monthly IWE_h data ranged between 2.4 (Mar.) and 3.7 (Aug. and Sept.), with a mean of 3.3 tons/ ha/ day, a STD of 0.46 tons/ ha /day and a CV of 14%. The main monthly effect showed that IWE_h was in the following significant order: Aug. = Sept. > Oct.> Nov.> Dec.> Jan.> Feb.> Mar.

Table 6 Effect of direction and month on the IWE_v (ton ha^{-1} day^{-1}) measured in the bare field surface during the second season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	60.9	76.0	3.3	33.8	21.8	61.1	55.6	83.3	49.5b
NW	56.0	72.7	8.5	51.8	55.6	195.6	166.1	166.7	96.6a
N	59.9	73.3	15.0	25.7	42.3	153.9	161.7	167.8	87.5a
NE	56.1	53.7	9.7	29.9	22.0	196.1	165.0	168.3	87.6a
Mean	58.2bc	68.9b	9.1d	35.3cd	35.4cd	151.7a	137.1a	146.5a	80.3

*Letters as explained in Table 2.

Table 7 Effect of direction and month on the IWE_h (ton ha^{-1} day^{-1}) measured in the cultivated field during the second season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	7.8	3.5	4.0	3.8	3.4	3.5	3.1	3.6	4.1a
NW	2.9	1.3	1.7	1.7	1.6	1.2	1.2	2.1	1.7b

N	1.7	5.2	6.0	5.8	5.4	4.9	4.6	1.4	4.4a
NE	2.5	4.8	2.7	2.7	2.7	2.7	2.6	2.4	2.9ab
Mean	3.7a	3.7a	3.6a	3.5a	3.3a	3.1a	2.9a	2.4a	3.3

*Abbreviations as explained in Table 1

Table 8 shows that the IWE_v data for the different directions in the cultivated field ranged between 0.41 (NE) and 6.9 (W) with a mean of 2.8 tons/ ha/ day, a STD of 2.9 tons/ ha/ day and a CV of 103.6%. The overall mean of IWEv of this field is about 2.6% that of the bare field in the first season. The main wind direction effect showed that IWE_v was in the following significant order: W > NW > N = NE. The table also shows that the monthly IWE_v data ranged between 1.5 (Sept.) and 7.4 (Mar.), with a mean of 2.8 tons/ ha/ day, a STD of 1.9 tons/ ha /day and a CV of 67.9%. The main monthly effect showed that IWE_v was in the following significant order: Mar.> Aug.> Oct. = Nov. = Dec. = Feb.> Jan.> Sept.

Table 8 Effect of direction and month on the IWE_v (ton ha^{-1} day^{-1}) measured in the cultivated field during the second season*

Direct.	Month								Mean
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
W	3.4	1.9	4.9	4.8	4.7	4.7	4.9	25.8	6.9a
NW	4.1	2.4	2.3	2.2	2.3	2.2	2.3	2.7	2.6b
N	1.9	1.3	1.0	0.9	1.0	0.9	1.0	0.8	1.1c
NE	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0.41c
Mean	2.6b	1.5b	2.2b	2.1b	2.1b	2.0b	2.2b	7.4a	2.8

*Letters as explained in Table 2

IV. DISCUSSION

In the bare fields, horizontal traps in all directions and months yielded significantly much higher IWE than vertical traps. The overall mean IWE_h value was 1.8 and 1.9 fold the overall mean IWE_V value in the first and second seasons, respectively. This was attributed to the fact that horizontal traps collected soil particles transported by the three mechanisms of wind erosion, namely saltation, surface creep and suspension, where as vertical traps collected particles transported by saltation only. The IWE measured by both traps in the first season were much higher than those measured in the second season The overall mean IWE_h and IWE_V in the first season were 1.3 and 1.4 fold those in the second season, respectively. This effect was attributed to the higher wind erosivity in the first season. The wind erosivity was 2483 and 2309.3 m^3/sec^3 for the first and second seasons, respectively (Abdelwahab, 2012).

In the cultivated fields, the overall mean of IWE_v yielded significantly much higher than that produced by IWE_h in the first season, but in the second season result was inverse with very meager increasing in the overall mean value of IWE_h. The ratio IWE_v/ IWE_h of the overall mean values was 1.4 and 0.85 in the first and second seasons, respectively. This effect is because Lucerne reduced wind erosivity and obstructed the movement of soil particles into the horizontal traps, much more than into the vertical traps in first season whereas in the second season reverse trend was found with very meager increased in IWE_h .This effect was attributed to the lower wind erosivity in the second season. Furthermore, plant cover in the cultivated fields greatly reduced IWE_h and IWE_v.

In general plant cover as a surface roughness element determines the extent to which air flow contacts the ground surface and influences the height of the mean aerodynamic surface and consequently reduces wind erosivity. Both height and density determine the effectiveness of plants in reducing wind erosivity. Chepil and Woodruff (1963) stated that grasses and legumes are the most efficient in establishing a dense cover. The results showed that IWE measured by both traps were greatly reduced in the cultivated fields in both seasons. In the first season, IWE_h and IWE_v in the cultivated fields were 2.1% and 5.3% those in the bare fields, respectively. In the second season, these ratios were 2.2% and 3.5%, respectively. This was attributed to the good protection offered by Lucerne to the ground from erosive winds. This finding agrees with previous findings of Farah (2003).

There is variation in the order of magnitude of the monthly IWE. The variation due to direction was much lower than monthly; due to the higher monthly variability of wind erosivity. The IWE values obtained in Aug. and Sept. were caused mainly by S and SW winds, which were stronger winds but shorter in duration. However the prevailing N. winds caused high IWE in Jan. (NNW), Feb. (NW) and Mar. (NW), and days of dust storms. Finally, the high temperature effects on pressure and wind velocity in summer caused the transportation of heavier and denser particles opposite effect of low temperature in (Oct., Nov. and Dec.). This finding agrees with previous findings Abuzied (2009) and Farah (2003), with emphasized on minimum sand transport recorded in November and December.

V. CONCLUSION

As expected the bare lands gave significantly higher mean IWE values than the Lucerne-cultivated field. The IWE_h in the bare land was 47 and 45.7 fold that of the cultivated field in the two successive seasons. Thus, cultivating the land with Lucerne will effectively protect the land from erosion. However, it is recommended to establish a shelterbelt, because of its added beneficial environmental effects, and because it permits the variation of the cropping pattern. Moreover growing summer and winter crops with appropriate crop residue management offer good land protection against soil erosion. However this does not preclude the establishment of a shelterbelt.

The results showed that the prevailing wind directions are north, north east and North West, but the southerly winds though of short duration are very strong. Comprehensive studies on wind velocity and direction should be undertaken in the early stages of establishing a scheme to help in making appropriate design of the shelterbelt. The River Nile State occupied large areas with varying metrological conditions. So there is a pressing need for establishing new meteorological stations in some appropriate locations.

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