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Research Article
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Fog Water Collection for Agriculture Use (Peanut Irrigation) Under Semi-Arid Region Conditions in North Coast of Egypt

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Abstract

Two field experiments were conducted at Marsa Matrouh Agricultural Research Farm during summer seasons of 2013 and 2014 using drip irrigation system, to evaluate the effect of some fog water harvesting models (f.w.h.m) of, (Double mesh had 220 stitches/cm^2 (model-1), Single layer mesh touching each other had 220 stitches/cm^2 (model-2), Double mesh had 120 stitches/cm^2 (model-3) and Single layer mesh touching each other had 120 stitches /cm^2 model-4) under some farmyard manure rates (20,30,40 m^3)/fad on groundnut productivity. Results indicated that, there were differences between studied factor, (f.w.h) model-1, was significant exposed its superiority on the total water amount harvested it during the two seasons led to give significant greatest values of pods, seeds yield/ Fadden, biological yield/fad., seed and harvest index, and water use efficiency. It is worthy to mention that, also led to enhance yield as compared by the other (f.w.h.m) during the two experimental seasons. Results revealed that, by increasing the amount of the added farmyard manure to improve the most values of the previous peanut traits significantly, during the two seasons. The interaction effect between f.w.h.m and farmyard manure rates showed significant effect, grow in peanut plants under the condition of f.w.h model-1 and fed by 30 or 40 m^3 of that fertilizer gave best significant values for most studied peanut traits compared with other treatments.

Keywords: Fog water; Manure; Peanut; Mesh; Model

Introduction

Fog is an environmental water resource of great importance. It plays an integral role in many diverse ecosystems. A very special part of the fog activities in the world today is focused on fog collection to provide water for managed use. One of the most exciting aspects of this resource is that in many regions the supply of water will be limited only by the number of collectors one chooses to install. In addition, since the source of the fog is normally the movement of marine stratocumulus deck over coastal mountains, the water quality is good and the water can be used for drinking and other domestic and agricultural purposes [1]. The latter experiments indicate that fog has been considered as a water resource in some arid or desert environments but it has never been developed as a serious water supply. Africa has arid and desert conditions in both the extreme north and the extreme south of the continent. Fog-water collection systems may have application at many locations in Africa but of date, there have been few experiments to verify this. One of the most interesting reports was of a tree in the Canary Islands, which as early as 1764, was said to have produced large amounts of fog-water for the islanders [1] The different aspects of the technology and the project results have been documented in the literature and it deserves strong consideration in regions that are arid or seasonally arid. Namibia is the first African country in which the possibility of using fog collection as a water supply for indigenous peoples is being evaluated. Yamen reported that, the potential to collect fog water for fresh water production was investigated in the mountains near Hajja, north capital city of Sana'a and inland from the Red Sea. In 2003, Yamen found that, best sites averaged 4.5 L/m^2/day over the 3-month dry winter period using LFCs fog collectors after successful initiation. The project was given over to the local people and local organization [2]. This application in Egypt depends on finding locations where there are high horizontal fluxes of fog water in regions with an acute water need. Fog has the potential to provide an alternative source of freshwater in semiarid and arid regions if harvested with simple and low-cost collection systems known as fog collectors. This application in Egypt depends on finding locations where there are high horizontal fluxes of fog water in regions with an acute water need. Peanut is planted in arid and semi-arid areas, it is very rich in protein and oil of good quality. Drought is one of the limiting factors to peanut yield in many countries [3,4] Groundnut (*Arachis hypogaea L.*) has an unique importance in our country either for local use or as foreign exchange earner. The soil texture of Egyptian belts is generally light and well drained. The farmyard manure is one of the very important treatments, which improves the sandy soil properties specially increasing its water hold capacity to save and increase the utilization efficiency of water irrigation. Venkataramana [5] indicated that organic manure has a profound effect on improving soil physical, chemical and biological properties and enhancing productivity of field crops. They also added that, groundnut fed by the application of FYM at 10 to 15 ton/fad increased the pod and haulm yields and improved the yield parameters like shelling percentage, 100 seed weight and sound mature kernel compared to the recommended dose of fertilizers. This study aims to evaluate some fog water harvesting models under different farmyard manure rates on groundnut productivity under the condition of Marsa Matrouh.

Materials and Methods

Two field experiment were conducted during the summer seasons 2013 and 2014 at the farm of Marsa Matrouh Agricultural Research Station, to evaluate the impact of some fog water harvesting models under different farm yard manure rates on yield, yield components and some chemical constituting of peanut (*Arachis hypogaea* L).

Experimental treatments

Fog water harvesting methods

Description of atrapanieblas: The mean structure is called

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atrapanieblas (Spanish, meaning trapping fog). It mainly consists of a large meshes made of poly propylene material suspended vertically to the wind direction at 100 m far from the sea water by hang it very taut, between two posts to collect the water droplets out of the fog. As the fog passing through the meshes, the fog with its droplets is pushed through the mesh by the wind. The droplets then collide with the fibers of the mesh and stay attached to them. When the droplets accumulate and grow, they drip down the mesh. Underneath, along the base a drip rail (Figure 1) to collect the fog water, which drips down the mash after it come in contact with the mesh. The dimensions of the mesh are 3 m high 17 m long. Thus, the area of one fog collector is 51 m^2. The base of the mesh is 2 m above the ground. The collected water in the drip rail is piped through PVC-pipes by gravity to small measured tank for each model. Every day at 7 Am clock the amount of harvested water was estimated, recorded and trans located to special big tank for each model its volume 1000 L (1 m^3). That tank was connected by drip irrigation system cover 9 sub plot for each model so, the total amount of harvested water during the growing season started form 20th of April before sowing at 15 days until 15th September the date of stop irrigation can be calculated.

The study covered four models of atrapaniebles as follow

Double mesh had 220 stitches /cm^2 with shade coefficient of 70%.

- Single layer mesh touching each other had 220 stitches /cm^2 with shade coefficient for each layer 70%.
- C- Double mesh had 120 stitches /cm^2 with shade coefficient of 50%.
- D- Single layer mesh touching each other had 120 stitches/cm^2 with shade coefficient for each layer 50%.

Farmyard manure fertilizer rates: To improve the hold capacity of experimental soil (sandy soil) and to save water irrigation, the study covered three farmyard manure rates as follow:

1-20 m^3/fed, 2- 30 m^3/fed, 3- 40 m^3/fed

The amount of farmyard for each rate was calculated according the area of the sub plot and added during soil preparation.

Soil mechanical and chemical analysis: To be in touch with the soil fertility after applying the three-farm yard manure, soil samples were collected from the experimental site before sowing and after harvesting to the depth of 30 cm and air dried for mechanical and chemical analysis that recorded in Table 1. In both seasons, the treatments were arranged in split plot design in three replications. The main plot was randomly devoted to the fog harvest models. The area of each was 31.5 m^2 (3.5 m × 9 m) each one consisted of three-sub plot. The sub plot was randomly devoted to the three farmyard manure rates. Each one, area was 10.5 m^2 (3 m × 3.5 m). It consisted of 5 rows/plot spaced at 60 cm apart and 3.5 m long. Calcium super phosphate (15.5% P_2O_5) at rate of 200 kg/fed, and potassium sulfate (48% K_2O) at rate of 50 kg /fed, Gypsum farm at rate of 500 kg / fed. Were added during land preparation, Sowing

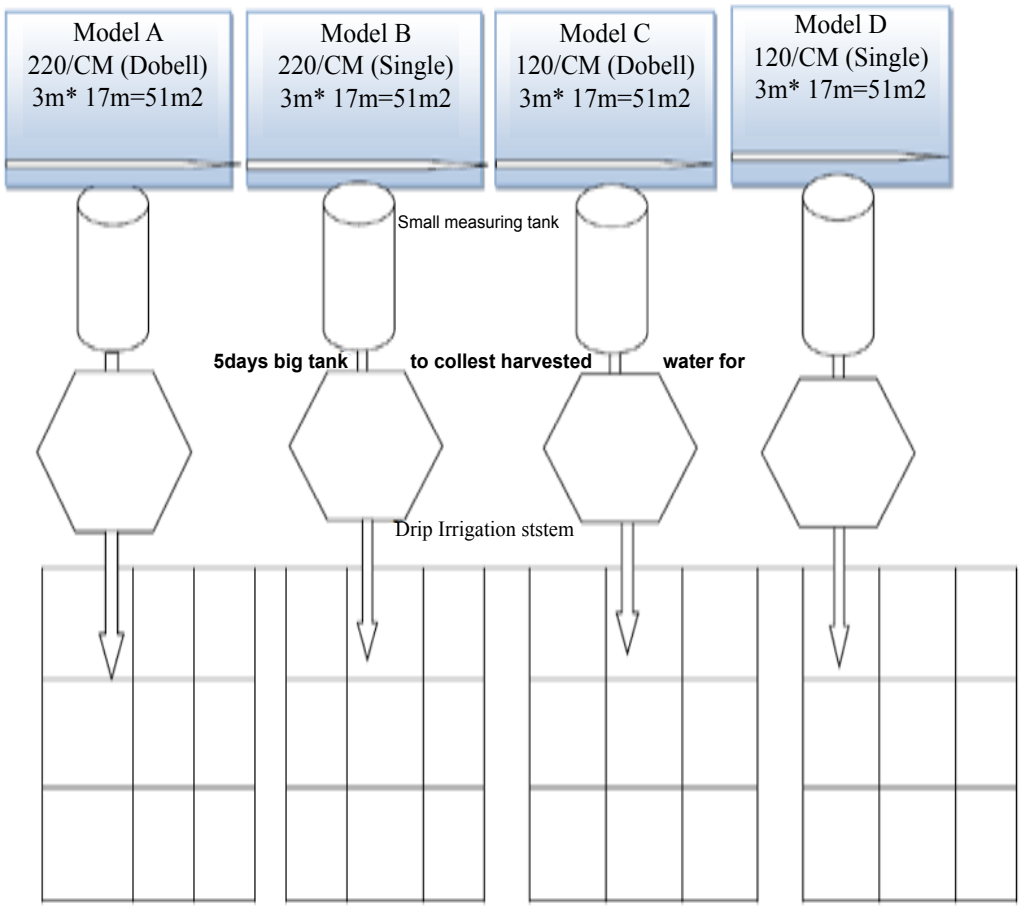

Figure 1: The outline drowning of fog water harvesting models.

Farmyard manure	Before sowing							
	Mechanical analysis				Chemical analysis			
	%clay	%silt	%sand	Texture	pH	Ec mm/cm³	%O.M	%O.C
Zero	2	6.6	91.4	sandy	8.2	3.4	0.12	0.07
After harvest								
20 m³	2.3	7.8	89.9	sandy	7.9	3.2	1.23	0.72
30 m³	2.8	8.6	88.6	sandy	8.0	3.0	1.34	0.78
40 m³	3.6	9.8	86.6	sandy	7.9	3.1	1.65	0.96

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Table 1: Mechanical and chemical analysis for soil samples of the experimental site before sowing and after harvesting (0-30 cm depth)*.

took place on May 5th each season, the drip irrigation system was used for irrigating the experiment during the two seasons. Each sup-plot contain five GR pipelines of hoses GR-diameter 16 mm at the distance of 20 cm had at rate of 4 L/h apart, so each dripper irrigated two halls. The irrigating was conducted every 5 days after sowing irrigation. It wealthy to mention that, the amount of water harvested form each model during 5 days was used to irrigate that treatment. Peanut seeds were inoculated with *Rhizobium spp* before planting it in hills at 10 cm apart three seeds in each. After germination, the plants in each hall were thinned in two plants.

Characteristics studied

Yield and yield component: All the plants of each plot were harvested and left for air dry then the plants weighted. All the pods of the plants were removed and weight to obtain.

3-Biological yield/Fadden (kg/fed), 4-pods yield Fadden (kg/fed), 5-Seed yield Fadden (kg/fed) 6- Seed index, 7-Harvest index=Economic yield / Biological yield × 100

8-Water use efficiency (kg/m³) Expressed as the weight of air-dried biological yield (kg/fed) or air-dried pods yield (kg/fed) and seed air-dried yield (kg/fed). computed for the different treatment by using the formula of El-Boraie [6], as follow:

WUE=Biological yield or pods yield and Seed yield (kg/fed)/ Evapotranspiration (m³/fed)

Statistical analysis

The analysis of variance was used for this experiment according to Jagdev [7] the least significant differences (L.S.D) test at the 5% level of probability was used to compare the differences between means. Consumptive use (m³/fed), the quantities of added water for the different treatment were recorded.

Results and Discussion

The biological, pods and seeds yield (kg/fed)

Results recorded in Table 2, show the variance between some fog water harvesting models, (F.W.H), farmyard manure rate and the interaction effect between them on biological, pods and seeds

Treatments		Season 2013			Season 2014		
Harvested water (m³/fed)	Manure (m³/fed)	Yield (kg/fed) of			Yield (kg/fed) of		
		Biological	pods	Seeds	Biological	pods	Seeds
*M(1) 1126 m³	20 m³	3289.16	1109.83	730.86	3334.96	1110	715.23
	30 m³	3393.35	1182.33	792.1	3393.76	1178	762.83
	40 m³	3423.33	1165.83	784.2	3444.83	1176.33	749.1
Mean		3368.61	1152.66	769.05	3391.18	1154.8	742.4
*M(2) 1036 m³	20 m³	2942.23	1024.67	658.23	2997.9	1037	668.3
	30 m³	3017.33	1061.67	691.1	3078.26	1068	693.73
	40 m³	3040.67	1088.5	694.2	3081.56	1083	681.9
Mean		3000.08	1058.28	681.18	3052.58	1062.7	681.31
*M(3) 992 m³	20 m³	2578.67	902	553.2	2593.3	904.16	562.63
	30 m³	2627.23	935	585.9	2670.46	923	582.27
	40 m³	2665.52	937	587.46	2701.96	933.66	594.27
Mean		2623.81	924.67	575.52	2655.24	920.28	579.72
*M(4) 880 m³	20 m³	2226.23	741.5	460.27	2286.43	747.33	479.3
	30 m³	2348.33	805	508.53	2380.3	803	527.63
	40 m³	2430.67	804.33	515.43	2463.33	816.33	530.93
Mean		2335.07	783.61	494.74	2376.69	788.89	512.62
GMI		2831.9	979.81	630.12	2868.92	981.65	629.01
Mean of Manure							
20 m³		2759.07	944.5	600.64	2803.15	949.65	606.37
30 m³		2846.56	996	644.41	2880.7	993	641.62
40 m³		2890.05	998.92	645.32	2922.92	1002.3	639.05
LSD at 5%							
Irrigation (I)		42.73	25.8	20.91	66.38	27.28	32
Manure (M)		46.05	23.75	18.9	39.02	20.12	28.45
I × M		61.2	31.56	25.11	51.85	26.72	37.81

*M=Model of atrapanieble (As given in material and methods)

Table 2: Evaluation of some fog water harvesting modes under some farmyard manure rates on the Fadden yield of Biological, pods, and Seeds of peanut in 2013 and 2014 seasons.

yield (kg/fed)during 2013 and 2014 seasons. It was noticed from the results recorded in Table 2 that, biological, pods and seeds yield (kg/fed) were significantly affected by the variance between the total water amount harvested from each F.W.H model during the two experimental seasons. Form studying the results in Table 2, significant positive effect was acquired by growing peanut plants irrigated by the greatest total amount of water harvested by model-1 (1126 and 1144 m^3) during 2013 and 2014 seasons respectively which its mesh had the greatest number of stitches /cm^2 (220) and consisted of double layer of mesh.

That reflect relying on gain the highest values of biological yield/fed (3368.61 and 3391.18 kg/fad), pod yield/fad (1152.70 and 1154.80 kg/fad) and seed yield/fed (769.05 and 742.40 kg/fad) in 2013 and 2014 seasons respectively. It is wealthy to mention that, the previous traits were decreased gradually by decreasing either number of mesh layer or stitches /cm^2. That companied by decreasing the total amount of harvested water from each during the two experimental seasons. These results are in general, agree with those obtained by Sabino [8], Gohri [9], Aboelill [10].

The remarkable effect was the interaction between F.W.H models and farmyard manure rates, significant effect of that source of variance, was found on the previous studied traits during 2013 and 2014 seasons. Cultivation peanut plants under the condition of irrigate it from the total amount of harvested water of model 1 and fed by 30 or 40 m^3 of farmyard manure gave the greatest values of biological (3423.33 kg/fad) pod (1182.33 kg/fad) and seed yield/fad (792.10 kg/fad) compared with the other treatments, in the first growing season. Similar findings had been observed in the second one.

Seed and harvest index

The averages of seed and Harvest index as affected by the different fog water harvesting models (F.W.H.M), some farmyard manure rate and the interaction between them in 2013 and 2014 seasons were recorded in Table 3. Results in Table 3 cleared that, (F.W.H) models significantly varied due to its effect on peanut seed and harvest index; it means the total water amount harvested effect from each one during the two experimental season, F.W.H model 1 and 2 exposed their superiority due to the total water amount harvested by them during 2013 (1126 m^3) and 2014 (1144 m^3), with its specification which explained before, resulted the greatest pods and seeds yield per plant and Fadden as well as biological yield/fad, shelling % and the lowest number of pod/100 gm. F.W.H. Model 1 increase peanut seed index significantly by (1.17%, 4.85% and 6.54%) as compared by F.W.H models 2, 3 and 4 of water during 2013 season respectively. The results of 2014 season took the same trend. These results may be due to the favor effect of increasing the total water amount added to irrigate peanut plant, led to in favor the vegetative growth, net assimilation rate biological yield /fed and seed yield/fed.

Regarding peanut harvest index as affected by the same factor, results in Table 3 showed significant effect of that factor during 2013 and 2014 seasons F.W.H, model 4. Secured the lowest harvest index (0.336 and 0.332) during 2013 and 2014 seasons compared with the other f.w.h. models that may be due to the harmful effect of the stress condition of drought caused by low total water amount harvested during the two growing seasons compared with model 2 and 3. These results are in the same line with those obtained by Venkataramana [5]. Respecting to the effect of farmyard manure rates, results recorded in ta Table 3 cleared that, during the two experimented seasons, peanut seed index and Harvest index were gradually increased by increasing the farmyard manure amount from 20 m^3/fed to 30 m^3 /fad. For example,

Treatments		Season 2013		Season 2014	
Harvested water (m^3/fed)	Manure (m^3/fed)	Seed index	Harvest index	Seed index	Harvest index
*M(1) 1126 m^3	20 m^3	75.48	0.34	75.81	0.33
	30 m^3	76.34	0.35	77.78	0.35
	40 m^3	77.63	0.34	78.41	0.34
Mean		76.48	0.34	77.34	0.34
*M(2) 1036 m^3	20 m^3	74.48	0.35	74.96	0.35
	30 m^3	75.66	0.35	76.35	0.35
	40 m^3	76.37	0.36	76.18	0.35
Mean		75.59	0.35	75.83	0.35
*M(3) 992 m^3	20 m^3	71.60	0.35	72.29	0.35
	30 m^3	73.48	0.36	72.41	0.35
	40 m^3	73.75	0.35	72.79	0.35
Mean		72.94	0.35	72.50	0.35
*M(4) 880 m^3	20 m^3	70.40	0.33	70.11	0.33
	30 m^3	72.12	0.34	71.53	0.34
	40 m^3	72.83	0.33	72.26	0.33
Mean		71.78	0.34	71.30	0.33
GMI		74.20	0.35	74.24	0.34
Mean of Manure					
20 m^3		72.82	0.34	73.35	0.34
30 m^3		74.24	0.35	74.54	0.34
40 m^3		75.30	0.35	75.14	0.34
LSD at 5%					
Irrigation (I)		0.80	0.00	0.85	0.00
Manure (M)		0.38	0.00	0.67	0.00
I × M		0.51	0.01	1.33	0.00

Table 3: Evaluation of some fog water harvesting modes under some farmyard manure rates on seed index and Harvest index of peanuts in 2013 and 2014 seasons.

in 2014 season seed index (%) was increased by 1.62% and 2.44% by adding 30 m^3 and 40 m^3 of farmyard manure as compared by 20 m^3 application, the results of Harvest index (%) during the 2013 and 2014 seasons took the same trend, with the exception of 40 m^3 of farmyard manure during the two seasons, that rate led to significant reduction on that trait. These results are in agreement with those obtained by Venkataramana [5]**.** As for the interaction effect between F.W.H models and farmyard manure (F.Y.M) rates showed significant effect on peanut seed and Harvest index during the two experimental seasons. Growing peanut plants irrigated by F.W.H model 1 which supplied peanut plants by 1126 m^3 and 1144 m^3 of water irrigation during 2013 and 2014 seasons, respectively and fed by 30 m^3 or 40 m^3 of (F.Y.M) during the two seasons recorded the greatest seed index (%) (76.34 or 77.63) and (77.76 or 78.4) compared by the other treatments. Significant effect was acquired by the interaction effect between F.W.H. models and (F.Y.M) rates on peanut harvest index. Growing peanut plants under the condition of F.W.H. model-2 which supplied the plant by 1036 m^3 or 1033 m^3 of water irrigation during 2013 and 2014 seasons and/fed by 40 m^3 of (F.W.H) gave the greatest harvest index (0.358 and 0.351), respectively compared with the other treatments.

Water use efficiency (kg/m^3)

The averages of water use efficiency (W.U.E) depending on Biological, pods and seeds (kg/m^3) as affected by the different fog water harvesting models (F.W.H.M), some farmyard manure rates and the interaction effect between them in 2013 and 2014 seasons were tabulated in Table 4. Result in Table 4 cleared that, (F.W.H) models significantly varied due to its effect on W.U.E Biological and seeds (kg/m^3) referring to the total water amount harvested from each one during the two experimental seasons. F.W.H model 1 surpassed the other (F.W.H) models on the total water amount harvested by it during 2013(1126 m^3) and 2014 (1144 m^3), it increased peanut W.U.E depending on biological (kg/m^3) significantly by 3.1%, 12.83% and 12.83% as compared by F.W.H models 2, 3 and 4 which harvested 1036 m^3, 992 m^3 and 880 m^3 of water during 2013 season respectively. As for peanut W.U.E depending on pod or seed, yield (kg)/fad results in Table 4 observed that model-1 of F.W.H continued its superiority to gave the best W.U.E depending on pod or seed yield (kg)/fad as compared with model 1. These results are previous confirmed by Sabino [8], Gohri [9], Aboelill [10].

Regarding to the effect of farmyard manure rates, results recorded in Table 4 cleared that, during the two experimental seasons, W.U.E depending on biological or pods and seeds yield(kg/fed) were gradually increased by increasing the farmyard manure amount from 20 m^3/fed to 30 m^3 or 40 m^3/fed. For example, in 2014 season, W.U.E depending on biological yield/fad was increased by 2.90% and 4.36% by adding 30 m^3 and 40 m^3 of farmyard manure as compared by 20 m^3 application, the results of W.U.E depending on pods and seeds (kg/m^3) during the 2013 and 2014 seasons took the same trend. These results confirmed the aim of adding the farmyard manure under the condition of sandy soil to improve its nutrients content including micronutrients at more appropriate amount and rate to crop, also the slow regular release of nutrient may well better to meet the requirements of peanut crop. Moreover, the utilization efficiency of water irrigation will be increased by increasing sandy soil holding capacity. Similar results had been described by Venkataramana [5]. The interaction between F.W.H models and (F.Y.M) rates showed significant effect on peanut W.U.E biological, pods and seeds (kg/m^3) during the two experiment seasons. Growing peanut plants irrigated by F.W.H model-1 which supplied

Treatments		Season 2013			Season 2014		
Harvested water (m^3/fed)	Manure (m^3/fed)	Water use efficiency (kg/m^3)			Water use efficiency (kg/m^3)		
		Biological	pods	seeds	Biological	pods	Seeds
*M(1) 1126 m^3	20 m^3	2.92	0.99	0.65	2.92	0.97	0.63
	30 m^3	3.01	1.05	0.70	2.97	1.03	0.67
	40 m^3	3.04	1.04	0.70	3.01	1.03	0.66
Mean		2.99	1.03	0.68	2.96	1.01	0.65
*M(2) 1036 m^3	20 m^3	2.84	0.99	0.64	2.90	1.00	0.65
	30 m^3	2.91	1.03	0.67	2.98	1.03	0.67
	40 m^3	2.94	1.05	0.67	2.98	1.05	0.66
Mean		2.90	1.02	0.66	2.96	1.03	0.66
*M(3) 992 m^3	20 m^3	2.60	0.91	0.56	2.62	0.92	0.57
	30 m^3	2.65	0.94	0.59	2.70	0.93	0.59
	40 m^3	2.69	0.95	0.59	2.73	0.95	0.60
Mean		2.65	0.93	0.68	2.68	0.93	0.59
*M(4) 880 m^3	20 m^3	2.53	0.84	0.52	2.57	0.84	0.54
	30 m^3	2.67	0.92	0.58	2.68	0.90	0.59
	40 m^3	2.76	0.91	0.59	2.77	0.92	0.59
Mean		2.65	0.89	0.56	2.67	0.89	0.58
GMI		2.80	0.97	0.62	2.82	0.96	0.62
Mean of Manure							
	20 m^3	2.72	0.93	0.59	2.75	0.93	0.60
	30 m^3	2.81	0.98	0.64	2.83	0.98	0.63
	40 m^3	2.86	0.99	0.64	2.87	0.99	0.63
LSD at 5%							
Irrigation (I)		0.02	0.03	0.02	0.06	0.03	0.03
Manure (M)		0.02	0.02	0.02	0.04	0.02	0.03
I × M		0.03	0.03	0.03	0.05	0.03	0.04

Table 4: Evaluation of some fog water harvesting modes under some manure rates on Water use efficiency (kg/m^3) in 2013 and 2014 seasons.

peanut plants by 1126 m^3 and 1144 m^3 of water irrigation during 2013 and 2014 seasons respectively and fed by 30 m^3 or 40 m^3 of farmyard manure gave the great W.U.E depending on biological (kg/m^3) (3.01 or 3.04) and (2.97 or 3.01) compared by adding 20 m^3 of farmyard manure. Peanut W.U.E pods and seeds (kg/m^3) took the same trend [11-15].

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