CHAPTER 4

RESULTS AND DISCUSSION

The results obtained from this investigation during the two growing seasons 2011/2012 and 2012/2013 were discussed under four main titles as follows:
Growth attributes.
Yield, yield components and water use efficiency.
Chemical compositions.
Economic evaluation.

4.1. Growth Attributes:

4.1.1. Plant height (cm):

Data presented in Table (5) indicated the effect of strip size of water harvesting system and (mineral nitrogen and biofertilization) on plant height (cm) at different growth stages (56 and 70 day after sowing) of barley grown during 2011/2012 and 2012/2013 growing successive seasons.

The mean values of the plant height were significantly affected by strip size of water harvesting system and (mineral nitrogen and biofertilization).

The plant height was gradually increased by increasing the catchment area up to (4: 1) (four times of cultivated area) with both growth stages during the first and second growing seasons, respectively.

During the two growing seasons, increasing the catchment area from the control treatment (without leaving catchment area) up to the largest catchment area (144 m^2) caused an increase in the plant height (cm). During the first season, the catchment area ratio (4: 1) gave the tallest plants (29.22 and 39.64 cm) with the first and second growth stages (56 and70 DAS), respectively. During the second season, the same trend was obtained, which were (28.48 and 38.55 cm) with the two growth stages (56 and 70 DAS) respectively. On the other side, the control treatment (without leaving catchment area) gave the shortest plants (21.75 and 26.64 cm) over two growth stages (56 and 70 DAS) respectively, during the first season and (21.67 and 25.94 cm) at the two growth stages (56 and 70 DAS) respectively, during the second season. In this respect, **Abelardo, (1996)** maintained that, water harvesting can increase soil moisture content by holding more run-off water from catchments area for the cropped area which was reflected on increasing plant growth due to increase in sink capacity. These results are in line with those optioned by **Hassan *et al.*, (1998)** and **Li *et al.*, (2000)**.

Concerning mineral nitrogen and biofertilization effects, data in Table (5) showed that, plant height was significantly affected by mineral nitrogen and biofertilization with the first and second growth stages (56 and 70 DAS) during the first and second growing seasons, respectively. 20 kg N/fed. with biofertilization treatment gave the tallest plants (28.32 and 36.07 cm) at the two growth stages (56 and 70 DAS) respectively, during the first season and (27.90 and 35.78 cm) at the two growth stages respectively, during the second season. The shortest plants (22.61 and 29.05 cm) during the first season and (22.34

Table (5): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on plant height (cm) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	11/12		12/13	
	56 Days	70 Days	56 Days	70 Days
H : C (A):				
Control	21.75	26.64	21.67	25.94
1 : 1	24.95	30.16	24.97	29.90
2 : 1	26.42	34.12	26.17	33.41
3 : 1	27.95	37.19	27.36	36.22
4 : 1	29.22	39.64	28.48	38.55
New L.S.D. $_{0.05}$	0.26	0.63	0.43	0.84
Fertilization (B):				
Without fertilization	22.61	29.05	22.34	28.35
10 Kg N/fed.	26.27	33.96	25.86	32.91
20 Kg N/fed.	27.59	34.83	27.17	34.66
Microbein	24.57	32.13	24.62	31.13
10 Kg N/fed.+ Microbein	27.00	35.25	26.49	33.99
20 Kg N/fed.+ Microbein	28.32	36.07	27.90	35.78
New L.S.D. $_{0.05}$	0.24	0.37	0.42	0.55
Interaction:				
AXB	0.53	0.82	0.94	1.23

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (6): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on plant height (cm) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		11/12		12/13	
		56 Days	70 Days	56 Days	70 Days
Control:					
	Without fertilization	18.20	22.90	18.34	22.30
	10 Kg N/fed.	21.40	26.47	21.14	25.59
	20 Kg N/fed.	23.52	27.62	23.30	27.47
	Microbein	20.96	26.05	21.18	25.24
	10 Kg N/fed.+ Microbein	22.59	28.06	22.34	26.81
	20 Kg N/fed.+ Microbein	23.84	28.72	23.72	28.23
(1 : 1):					
	Without fertilization	21.73	26.94	21.64	26.34
	10 Kg N/fed.	25.11	30.00	24.92	29.34
	20 Kg N/fed.	26.14	30.82	25.94	31.31
	Microbein	24.06	29.42	24.85	29.11
	10 Kg N/fed.+ Microbein	25.69	31.41	25.50	30.72
	20 Kg N/fed.+ Microbein	26.96	32.36	26.96	32.61
(2 : 1):					
	Without fertilization	23.32	30.02	23.06	29.13
	10 Kg N/fed.	26.85	34.51	26.55	33.42
	20 Kg N/fed.	27.84	35.37	27.53	35.33
	Microbein	24.74	32.55	25.29	31.53
	10 Kg N/fed.+ Microbein	27.23	35.73	26.59	34.61
	20 Kg N/fed.+ Microbein	28.55	36.57	28.02	36.47
(3 : 1):					
	Without fertilization	24.57	32.42	24.08	31.15
	10 Kg N/fed.	28.37	38.14	27.84	36.82
	20 Kg N/fed.	29.39	38.54	28.86	38.25
	Microbein	26.09	35.25	25.53	33.95
	10 Kg N/fed.+ Microbein	28.96	38.99	28.26	37.62
	20 Kg N/fed.+ Microbein	30.33	39.79	29.58	39.50
(4 : 1):					
	Without fertilization	25.25	32.97	24.58	32.82
	10 Kg N/fed.	29.62	40.69	28.83	39.40
	20 Kg N/fed.	31.04	41.83	30.24	40.94
	Microbein	27.01	37.41	26.23	35.84
	10 Kg N/fed.+ Microbein	30.51	42.04	29.76	40.20
	20 Kg N/fed.+ Microbein	31.90	42.90	31.23	42.10
New L.S.D. $_{0.05}$		0.53	0.82	0.94	1.23

Control: Without catchment area.

and 28.35 cm) during the second season at the two growth stages (56 and 70 DAS) respectively, were recorded by the control treatment (without mineral nitrogen and biofertilization). In this respect, **Farrag *et al.*, (2012)** reported that, *bacillus amendment* enhanced the length of wheat and barley plants in both non-contaminated and contaminated soils, also **Tarun, (2013)** showed that fertilizer N at a rate of 80 kg/ha with both (*Azotobacter+Azospirillum*) inoculations were found to be the most responsive, with significantly increased in parley plants height. **Amanullah *et al.*, (2011)** found the same trend.

The increase in the plant height may be due to increase in cell development with increasing level of N treated to be large and also had higher meristematic activates, formation and functioning of protoplasm and may be due to mineral nitrogen encourages cell elongation and cell division. Also, it could be concluded that inoculation of barley grains with biofertilization led to an increase in plant height. This increase is most probably due to the principal mechanism that biofertilization could benefit the plant growth during fixing of molecular mineral nitrogen and its transfer to the plant as direct effect on plant growth hormones auxins, (GA_S) and (CK_S) that biofertilization could release in the root media and effect its growth and extension positively **(El-Khawas, 1990).** These results are in accordance with those obtained by **Gomma, (1992), Hassan *et al.*, (1998)** and **Attia, (2005).**

The effects of interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) on plant height (cm) with the two growth stages (56 and 70 DAS) of barley grown during 2011/2012 and 2012/2013 growing seasons were illustrated in Table (6).

It was found that, the interaction of the two factors (strip size of water harvesting system x mineral nitrogen and biofertilization) was significant for plant height (cm) with the two growth stages (56 and 70 DAS) during the first and second growing seasons.

It was noticed that, the interaction treatment ((4: 1) ratio with mineral nitrogen at a rate of 20 kg/fed. + biofertilization) recorded the highest mean values of plant height (31.90 and 42.90 cm) with the two growth stages (56 and 70 DAS) respectively, during the first season and (31.23 and 42.10 cm) with the two growth stages (56 and 70 DAS) respectively, during the second season. The lowest values (18.20 and 22.90 cm) with the two growth stages (56 and 70 DAS) respectively, during the first season and (18.34 and 22.30 cm) with the two growth stages (56 and 70 DAS) respectively, during the second season were recorded by the interaction treatment (without leaving catchment area and without (mineral nitrogen and biofertilization)). These results agreement with those reported by **Panda *et al.,* (1988)**.

4.1.2. Leaf area (cm^2)/m^2:

The effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on leaf area/m^2 with different growth stages of barley grown during 2011/2012 and 2012/2013 growing seasons were presented in Table (7).

The analysis of variance showed that, this character was significantly affected by the strip size of water harvesting system and (mineral nitrogen and biofertilization) over the two growth stages during the two growing seasons.

The largest catchment area (4: 1) showed the highest mean values (9924 and 11900 cm^2/m^2) with the two growth stages (56 and 70 DAS) respectively, during the first season and (9541 and 11451 cm^2/m^2) with the two growth stages (56 and 70 DAS) respectively, during the second season. While, the lowest values (6639 and 8030 cm^2/m^2) with the two growth stages (56 and 70 DAS) respectively, during the first season and (6312 and 7316 cm^2/m^2) at the two growth stages (56 and 70 DAS) respectively, during the second season were recorded by without leaving catchment area treatment.

The increase in leaf area/m^2 may be due to water harvesting can increase soil moisture content by holding runoff water from the catchments area within the cropped area and improve soil moisture storage, prolong the period of moisture availability and enhance growth of plants. The water supply (storage at the root zone) due to water function in plant growth can be summarized as follow : 1. Major constituent of physiologically active tissue and 2. An essential for the maintenance of turgidity necessary for cell in largamente and growth consequently improving the growth characters. These results are in accordance with those obtained by **Misra and Sen, (1981)** and **Attia, (2005)**.

The leaf area/m^2 was significantly affected by mineral nitrogen and biofertilization with the two growth stages during the two growing seasons. The mineral nitrogen at a rate of 20 kg/fed. with biofertilization recorded the highest values (8812 and 10530 cm^2/m^2) with the two growth stages (56 and 70 DAS) respectively, during the first season. During the second season, the same trend was obtained, which were (8486 and 10078 cm^2/m^2) with the two growth stages (56 and 70 DAS), respectively. On the other hand, the lowest values (7685 and 9135 cm^2/m^2) at the two growth stages (56 and 70 DAS) respectively, during the first season and (7014 and 8038 cm^2/m^2) at the two growth stages (56 and 70 DAS) respectively, during the second season were recorded by the control treatment (without mineral nitrogen and biofertilization).

It was found that, the interaction of the two factors (strip size of water harvesting system x mineral nitrogen and biofertilization) was significant for leaf area/m^2 with the two growth stages (56 and 70 DAS) during the first and second growing seasons.

Results presented in Table (8) indicated the effects of the interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) on leaf area/m^2 at different growth stages of barley grown in 2011/2012 and 2012/2013 seasons. The interaction treatment ((4: 1) with mineral nitrogen at a rate of 20 kg/fed. + biofertilization) recorded the highest mean values (10438 and 12543 cm^2/m^2) with the two growth stages (56 and 70 DAS) respectively, during the first season and (10114 and 12225 cm^2/m^2) with the two growth stages (56 and 70 DAS) respectively, during the second season. On the other hand, the lowest values (6211 and 7221 cm^2/m^2) at the two growth stages (56 and 70 DAS) respectively, during the first season and (5619 and 5992 cm^2/m^2) at the two growth stages (56 and 70 DAS) respectively, during the second season were obtained by the interaction treatment (without leaving catchment area and without (mineral nitrogen and biofertilization)).

Table (7): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on leaf area/m^2 (cm^2) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	11/12		12/13	
	56 Days	70 Days	56 Days	70 Days
H : C (A):				
Control	6639	8030	6312	7316
1 : 1	7601	8949	7282	8395
2 : 1	8424	10062	8070	9456
3 : 1	9245	11013	8827	10477
4 : 1	9924	11900	9541	11451
New L.S.D. $_{0.05}$	62.79	82.22	66.40	78.43
Fertilization (B):				
Without fertilization	7685	9135	7014	8038
10 Kg N/fed.	8386	10062	8120	9585
20 Kg N/fed.	8620	10361	8312	9877
Microbein	8122	9626	7846	9184
10 Kg N/fed.+ Microbein	8575	10230	8259	9753
20 Kg N/fed.+ Microbein	8812	10530	8486	10078
New L.S.D. $_{0.05}$	78.35	80.87	70.12	65.42
Interaction:				
AXB	174.85	180.66	156.73	146.34

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (8): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on leaf area/m^2 (cm^2) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		11/12		12/13	
		56 Days	70 Days	56 Days	70 Days
Control:					
	Without fertilization	6211	7221	5619	5992
	10 Kg N/fed.	6444	7871	6198	7273
	20 Kg N/fed.	6945	8372	6679	7783
	Microbein	6371	7799	6131	7239
	10 Kg N/fed.+ Microbein	6759	8201	6526	7621
	20 Kg N/fed.+ Microbein	7106	8714	6720	7989
(1 : 1):					
	Without fertilization	7069	8311	6404	7187
	10 Kg N/fed.	7586	8910	7335	8465
	20 Kg N/fed.	7753	9162	7496	8704
	Microbein	7475	8849	7242	8410
	10 Kg N/fed.+ Microbein	7760	9108	7503	8653
	20 Kg N/fed.+ Microbein	7964	9353	7710	8951
(2 : 1):					
	Without fertilization	7665	9401	7048	8225
	10 Kg N/fed.	8462	10169	8153	9662
	20 Kg N/fed.	8682	10341	8365	9823
	Microbein	8200	9707	7916	9226
	10 Kg N/fed.+ Microbein	8651	10251	8335	9739
	20 Kg N/fed.+ Microbein	8884	10501	8602	10059
(3 : 1):					
	Without fertilization	8502	10045	7655	8949
	10 Kg N/fed.	9413	11186	9211	10740
	20 Kg N/fed.	9471	11499	9101	11042
	Microbein	8969	10512	8643	10119
	10 Kg N/fed.+ Microbein	9446	11297	9067	10847
	20 Kg N/fed.+ Microbein	9670	11541	9285	11168
(4 : 1):					
	Without fertilization	8979	10696	8343	9836
	10 Kg N/fed.	10026	12172	9705	11786
	20 Kg N/fed.	10248	12431	9920	12033
	Microbein	9594	11261	9300	10925
	10 Kg N/fed.+ Microbein	10257	12293	9865	11903
	20 Kg N/fed.+ Microbein	10438	12543	10114	12225
New L.S.D. $_{0.05}$		174.85	180.66	156.73	146.34

Control: Without catchment area.

4.1.3. Leaf area index:

Data presented in Table (9) indicated the effect of strip size of water harvesting system and (mineral nitrogen and biofertilization) on leaf area index with the different growth stages of barley grown during 2011/2012 and 2012/2013 growing seasons.

The mean values of the leaf area index were significantly affected by strip size of water harvesting system and (mineral nitrogen and biofertilization).

Increasing the catchment area from the control treatment (without leaving catchment area) up to the largest catchment area (144 m^2) caused an increase in the mean values of leaf area index. The catchment area (4: 1) gave the highest values (0.99 and 1.19) at the two growth stages (56 and 70 DAS) respectively, during the first season and (0.95 and 1.15) at the two growth stages (56 and 70 DAS) respectively, during the second season. On the other side, the lowest values were recorded by without leaving catchment area of the strip size of water harvesting system (0.66 and 0.80) with the two growth stages (56 and 70 DAS) respectively, during the first season and (0.63 and 0.73) with the two growth stages (56 and 70 DAS) respectively, during the second season. In this respect, **Attia, (2005)** found similar results.

Results presented in Table (9) revealed that, mineral nitrogen and biofertilization treatments had significant effects on leaf area index with the two growth stages (56 and 70 DAS) during the two growing seasons.

Increasing mineral nitrogen from control up to 20 kg/fed. with biofertilization significantly increased the mean values of leaf area index (0.88 and 1.05) at (56 and 70 DAS) respectively, during the first season and (0.85 and 1.01) at (56 and 70 DAS) respectively, during the second season while, the lowest values (0.77 and 0.92) at the two growth stages (56 and 70 DAS) respectively, during the first season and (0.70 and 0.80) at (56 and 70 DAS) respectively, during the second season were recorded by the control treatment (without mineral nitrogen and biofertilization).

Such increase in leaf area index is regular and logic because these results may be attributed to the increase in average leaf area under the same treatments as well as at the same ages. The present results are in general agreement with those obtained by **Attia, (2005)** who found that, leaf area index increased with increasing the ratio between contributed (catchment) area and cultivated area.

It was found that the interaction of the two factors (strip size of water harvesting system x mineral nitrogen and biofertilization) was significant for leaf area index with the two growth stages (56 and 70 DAS) during the first and second seasons.

Data presented in Table (10) indicated the effect of interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) on leaf area index with different growth stages of barley grown in 2011/2012 and 2012/2013 seasons.

At the two growth stages (56 and 70 DAS) respectively, during the first season, the interaction treatment (144 m2 with 20 kg N /fed. + biofertilization) recorded the highest mean values of leaf area index (1.04 and 1.25) and (1.01 and 1.22) at the same stages

Table (9): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on leaf area index (L.A.I.) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	11/12		12/13	
	56 Days	70 Days	56 Days	70 Days
H : C (A):				
Control	0.66	0.80	0.63	0.73
1 : 1	0.76	0.89	0.73	0.84
2 : 1	0.84	1.01	0.81	0.95
3 : 1	0.92	1.10	0.88	1.05
4 : 1	0.99	1.19	0.95	1.15
New L.S.D. $_{0.05}$	0.0066	0.0078	0.0058	0.0084
Fertilization (B):				
Without fertilization	0.77	0.92	0.70	0.80
10 Kg N/fed.	0.84	1.01	0.81	0.96
20 Kg N/fed.	0.86	1.04	0.83	0.99
Microbein	0.81	0.96	0.78	0.92
10 Kg N/fed.+ Microbein	0.86	1.02	0.83	0.98
20 Kg N/fed.+ Microbein	0.88	1.05	0.85	1.01
New L.S.D. $_{0.05}$	0.0082	0.0086	0.0076	0.0069
Interaction:				
AXB	0.0182	0.192	0.0170	0.156

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (10): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on leaf area index (L.A.I.) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		11/12		12/13	
		56 Days	70 Days	56 Days	70 Days
Control:					
	Without fertilization	0.62	0.72	0.56	0.60
	10 Kg N/fed.	0.64	0.79	0.62	0.73
	20 Kg N/fed.	0.69	0.84	0.67	0.78
	Microbein	0.64	0.78	0.61	0.72
	10 Kg N/fed.+ Microbein	0.68	0.82	0.65	0.76
	20 Kg N/fed.+ Microbein	0.71	0.87	0.67	0.80
(1 : 1):					
	Without fertilization	0.71	0.83	0.64	0.72
	10 Kg N/fed.	0.76	0.89	0.73	0.85
	20 Kg N/fed.	0.78	0.92	0.75	0.87
	Microbein	0.75	0.88	0.72	0.84
	10 Kg N/fed.+ Microbein	0.78	0.91	0.75	0.87
	20 Kg N/fed.+ Microbein	0.80	0.94	0.77	0.90
(2 : 1):					
	Without fertilization	0.77	0.94	0.70	0.82
	10 Kg N/fed.	0.85	1.02	0.82	0.97
	20 Kg N/fed.	0.87	1.03	0.84	0.98
	Microbein	0.82	0.97	0.79	0.92
	10 Kg N/fed.+ Microbein	0.87	1.03	0.83	0.97
	20 Kg N/fed.+ Microbein	0.89	1.05	0.86	1.01
(3 : 1):					
	Without fertilization	0.85	1.00	0.77	0.89
	10 Kg N/fed.	0.94	1.12	0.92	1.07
	20 Kg N/fed.	0.95	1.15	0.91	1.10
	Microbein	0.90	1.05	0.86	1.01
	10 Kg N/fed.+ Microbein	0.94	1.13	0.91	1.08
	20 Kg N/fed.+ Microbein	0.97	1.15	0.93	1.12
(4 : 1):					
	Without fertilization	0.90	1.07	0.83	0.98
	10 Kg N/fed.	1.00	1.22	0.97	1.18
	20 Kg N/fed.	1.02	1.24	0.99	1.20
	Microbein	0.96	1.13	0.93	1.09
	10 Kg N/fed.+ Microbein	1.03	1.23	0.99	1.19
	20 Kg N/fed.+ Microbein	1.04	1.25	1.01	1.22
New L.S.D. $_{0.05}$		0.0182	0.192	0.0170	0.156

Control: Without catchment area.

during the second season. On the other side, the lowest mean values (0.62 and 0.72) with the two growth stages (56 and 70 DAS) respectively, during the first season and (0.56 and 0.60) with the two growth stages (56 and 70 DAS) respectively, during the second season were recorded by the interaction treatment (without leaving catchment area of the strip size of water harvesting system in the control treatment of mineral nitrogen and biofertilization). The trend of results of leaf area index behaved the same as that of the leaf area/m^2 under the same studied factors and the interaction between them at both stages for both seasons.

4.1.4. Specific leaf weight (SLW) "mg/cm^2":

With regard to specific leaf weight (mg/cm^2), the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on this character with different growth stages of barley grown during 2011/2012 and 2012/2013 growing seasons were presented in Table (11).

The analysis of variance showed that, specific leaf weight was significantly affected by the strip size of water harvesting system and (mineral nitrogen and biofertilization) only, with the second growth stage (70 DAS) during the two growing seasons but, at first growth stage (56 DAS), this character was not significantly affected by this studied factor in the first and second seasons respectively.

The catchment area ratio (2: 1) (two times of cultivated area) showed the highest mean value (5.02 mg/cm^2) at (70 DAS) during the first season, while during the second season, the highest mean value (4.80 mg/cm^2) at (70 DAS) was obtained by the catchment area (4: 1) which gave the same value by using the catchment area (1: 1) or (3: 1). On the other hand, lowest values (4.99 and 4.79 mg/cm^2) were recorded by without leaving catchment area at (70 DAS) during the first and second seasons, respectively.

Concerning mineral nitrogen and biofertilization effect, data presented in Table (11) showed that, the control treatment (without mineral nitrogen and biofertilization) gave the highest specific leaf weight (5.01 and 4.82 mg/cm^2) at (70 DAS) during the first and second seasons, respectively, while the lowest values (4.99 and 4.78 mg/cm^2) at (70 DAS) were recorded by plants received 10 kg N/fed. with biofertilization during the first and the second seasons, respectively.

From data presented in Table (12), it was found that the interaction of the two factors (size strip of water harvesting system x mineral nitrogen and biofertilization) was significant for specific leaf weight (mg/cm^2) at the second growth stage (70 DAS) during the first season and with the two growth stages (56 and 70 DAS) during the second one.

4.1.5. Relative growth rate (RGR) "gm/gm/day":

Pertaining the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on relative growth rate (RGR) with the different growth stages of barley grown during 2011/2012 and 2012/2013 seasons were presented in Table (13).

Table (11): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on specific leaf weight (S.L.W.) (mg/cm^2) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	11/12		12/13	
	56 Days	70 Days	56 Days	70 Days
H : C (A):				
Control	4.97	4.99	4.89	4.79
1 : 1	4.98	4.99	4.91	4.80
2 : 1	4.98	5.02	4.91	4.79
3 : 1	4.97	4.99	4.92	4.80
4 : 1	4.95	5.01	4.91	4.80
New L.S.D. $_{0.05}$	N.S	0.012	N.S	0.009
Fertilization (B):				
Without fertilization	4.95	5.01	4.92	4.82
10 Kg N/fed.	4.98	5.00	4.91	4.80
20 Kg N/fed.	4.97	5.00	4.92	4.79
Microbein	4.97	4.99	4.90	4.79
10 Kg N/fed.+ Microbein	4.98	4.99	4.91	4.78
20 Kg N/fed.+ Microbein	4.97	5.00	4.88	4.79
New L.S.D. $_{0.05}$	N.S	0.008	N.S	0.01
Interaction:				
AXB	N.S	0.017	0.077	0.021

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (12): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on specific leaf weight (S.L.W.) (mg/cm^2) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		11/12	12/13	
		70 Days	56 Days	70 Days
Control:				
	Without fertilization	5.01	4.92	4.80
	10 Kg N/fed.	4.99	4.92	4.78
	20 Kg N/fed.	4.99	4.93	4.79
	Microbein	4.98	4.90	4.78
	10 Kg N/fed.+ Microbein	4.98	4.91	4.78
	20 Kg N/fed.+ Microbein	4.98	4.76	4.78
(1 : 1):				
	Without fertilization	4.99	4.92	4.83
	10 Kg N/fed.	4.99	4.90	4.80
	20 Kg N/fed.	5.00	4.91	4.79
	Microbein	4.98	4.90	4.80
	10 Kg N/fed.+ Microbein	4.99	4.90	4.78
	20 Kg N/fed.+ Microbein	4.99	4.90	4.80
(2 : 1):				
	Without fertilization	5.03	4.90	4.82
	10 Kg N/fed.	5.02	4.92	4.78
	20 Kg N/fed.	5.03	4.93	4.79
	Microbein	5.00	4.91	4.78
	10 Kg N/fed.+ Microbein	5.00	4.90	4.78
	20 Kg N/fed.+ Microbein	5.02	4.92	4.80
(3 : 1):				
	Without fertilization	5.02	4.92	4.83
	10 Kg N/fed.	4.99	4.92	4.82
	20 Kg N/fed.	4.99	4.92	4.80
	Microbein	4.98	4.91	4.80
	10 Kg N/fed.+ Microbein	4.99	4.92	4.78
	20 Kg N/fed.+ Microbein	4.99	4.93	4.80
(4 : 1):				
	Without fertilization	5.02	4.93	4.83
	10 Kg N/fed.	5.01	4.90	4.80
	20 Kg N/fed.	5.00	4.90	4.79
	Microbein	5.01	4.90	4.81
	10 Kg N/fed.+ Microbein	5.01	4.90	4.80
	20 Kg N/fed.+ Microbein	5.01	4.91	4.79
New L.S.D. $_{0.05}$		0.017	0.077	0.021

Control: Without catchment area.

Table (13): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on relative growth rate (R.G.R.) (gm/gm/day) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	11/12		12/13	
	56-63 Days	63-70 Days	56-63 Days	63-70 Days
H : C (A):				
Control	0.0163	0.0140	0.0157	0.0132
1 : 1	0.0152	0.0127	0.0148	0.0121
2 : 1	0.0152	0.0127	0.0143	0.0113
3 : 1	0.0155	0.0121	0.0134	0.0109
4 : 1	0.0153	0.0121	0.0130	0.0107
New L.S.D. $_{0.05}$	N.S	N.S	N.S	N.S
Fertilization (B):				
Without fertilization	0.0152	0.0126	0.0133	0.0111
10 Kg N/fed.	0.0156	0.0128	0.0136	0.0116
20 Kg N/fed.	0.0157	0.0127	0.0151	0.0119
Microbein	0.0152	0.0125	0.0130	0.0110
10 Kg N/fed.+ Microbein	0.0156	0.0127	0.0145	0.0121
20 Kg N/fed.+ Microbein	0.0158	0.0130	0.0159	0.0123
New L.S.D. $_{0.05}$	N.S	N.S	0.001	0.0009
Interaction:				
AXB	N.S	N.S	N.S	N.S

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

It is clear that, the mean values of relative growth rate (gm/gm/day) were not significantly affected by the strip size of water harvesting system at two growth stages during the two growing seasons.

The tabulated results showed that, mineral nitrogen and biofertilization significantly increased the relative growth rate (gm/gm/day) of barley plants with the two growth stages (56-63 and 63-70 DAS) only, during the second season whereas, the treatment of 20 kg N/fed. with biofertilization gave the heights mean values of relative growth rate (0.0159 and 0.0123 gm/gm/day) with the two growth stage respectively, while the lowest mean values (0.0133 and 0.0111 gm/gm/day) with the two growth stages (56-63 and 63-70 DAS) respectively, during the second season were obtained by control treatment (without mineral nitrogen and biofertilization).

The interaction between the studied factors (strip size of water harvesting system x mineral nitrogen and biofertilization) showed no significant effect on relative growth rate (gm/gm/day) with the two growth stages during both growing seasons.

4.1.6. Total chlorophyll (SPAD):

The total chlorophyll (SPAD) had been affected by strip size of water harvesting system and (mineral nitrogen and biofertilization) with the different growth stages (56 and 70 DAS) of barley grown during 2011/2012 and 2012/2013 experiments growing seasons as shown in Table (14).

The total chlorophyll reached its maximum by increasing the catchment area up to 144 m^2. Increasing the catchment area from the control treatment (without leaving catchment area) up to the largest catchment area caused an increase in the total chlorophyll (38.83 and 40.22 %) with the two growth stages (56 and 70 DAS) respectively, during the first season. During the second season, the same trend was obtained, which were (38.53 and 39.99 %) with the two growth stages (56 and 70 DAS) respectively, compared with control treatment (without leaving catchment area) which recorded the lowest values (34.33 and 35.04 %) with two growth stages (56 and 70 DAS) respectively, during the first season and (34.30 and 34.91 %) with two growth stages (56 and 70 DAS) respectively, during the second one. These results agree with those of **Attia, (2005)** who reported that, total chlorophyll increased with increasing the ratio between contributed area and cultivated area.

Data in Table (14) showed that the mineral nitrogen and biofertilization had a significant effect on total chlorophyll with two growth stages during both growing seasons. The highest values of the total chlorophyll (37.99 and 38.88 %) at (56 and 70 DAS) respectively, during the first season and (37.85 and 38.70 %) at (56 and 70 DAS) respectively, during the second season were obtained by using 20 kg N/fed. with biofertilization treatment. While, the lowest values (34.14 and 35.76) with the two growth stages (56 and 70 DAS) respectively, during the first season and (33.93 and 35.30 %) with (56 and 70 DAS) respectively, during the second one were recorded by without mineral nitrogen and biofertilization (control treatment). Similar findings were pointed out by **Broumand *et al.*, (2010)**.

Table (14): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on total chlorophyll (S.P.A.D.) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	11/12		12/13	
	56 Days	70 Days	56 Days	70 Days
H : C (A):				
Control	34.33	35.04	34.30	34.91
1 : 1	35.66	36.84	35.42	36.36
2 : 1	36.72	38.19	36.35	37.40
3 : 1	37.88	39.34	37.54	38.92
4 : 1	38.83	40.22	38.53	39.99
New L.S.D. $_{0.05}$	0.436	0.324	0.404	0.322
Fertilization (B):				
Without fertilization	34.14	35.76	33.93	35.30
10 Kg N/fed.	37.32	38.38	36.97	37.85
20 Kg N/fed.	37.86	38.76	37.51	38.17
Microbein	35.37	37.36	35.17	36.87
10 Kg N/fed.+ Microbein	37.42	38.42	37.14	38.19
20 Kg N/fed.+ Microbein	37.99	38.88	37.85	38.70
New L.S.D. $_{0.05}$	0.337	0.343	0.431	0.419
Interaction:				
AXB	0.751	0.764	0.960	0.929

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (15): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on total chlorophyll (S.P.A.D.) at different growth stages of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		11/12		12/13	
		56 Days	70 Days	56 Days	70 Days
Control:					
	Without fertilization	31.88	33.24	31.80	32.99
	10 Kg N/fed.	34.81	35.40	34.53	35.20
	20 Kg N/fed.	34.99	35.57	34.72	35.27
	Microbein	34.15	34.86	34.11	34.62
	10 Kg N/fed.+ Microbein	34.94	35.49	35.01	35.50
	20 Kg N/fed.+ Microbein	35.22	35.68	35.63	35.86
(1 : 1):					
	Without fertilization	33.41	34.90	33.07	34.33
	10 Kg N/fed.	36.39	37.23	36.03	36.68
	20 Kg N/fed.	36.58	37.45	36.22	36.82
	Microbein	34.40	36.73	34.33	36.11
	10 Kg N/fed.+ Microbein	36.46	37.25	36.10	36.91
	20 Kg N/fed.+ Microbein	36.75	37.45	36.78	37.29
(2 : 1):					
	Without fertilization	34.26	35.98	33.91	35.37
	10 Kg N/fed.	37.13	38.52	36.76	37.45
	20 Kg N/fed.	38.42	39.09	38.04	38.13
	Microbein	35.37	37.82	35.01	37.17
	10 Kg N/fed.+ Microbein	37.22	38.60	36.85	37.86
	20 Kg N/fed.+ Microbein	37.90	39.13	37.53	38.42
(3 : 1):					
	Without fertilization	35.18	37.00	35.02	36.54
	10 Kg N/fed.	38.50	39.85	38.11	39.26
	20 Kg N/fed.	39.22	40.47	38.83	39.78
	Microbein	36.38	38.44	36.04	37.79
	10 Kg N/fed.+ Microbein	38.60	39.80	38.22	39.76
	20 Kg N/fed.+ Microbein	39.41	40.51	39.01	40.38
(4 : 1):					
	Without fertilization	35.98	37.66	35.89	37.26
	10 Kg N/fed.	39.78	40.90	39.41	40.66
	20 Kg N/fed.	40.10	41.22	39.74	40.87
	Microbein	36.57	38.97	36.37	38.66
	10 Kg N/fed.+ Microbein	39.86	40.97	39.49	40.94
	20 Kg N/fed.+ Microbein	40.70	41.62	40.28	41.56
New L.S.D. $_{0.05}$		0.751	0.764	0.960	0.929

Control: Without catchment area.

The increase in total chlorophyll may be due to an increase in vegetative growth of plants due to water supply in the root zone and increase the moisture content by increasing the ratio between catchment area to the cultivated area and may be due to increase in the plant leave area (cm^2), increase in vegetative growth of plant, and increase in the leave area duration which enhanced the growth of barley plants.

Regarding the interaction, it was found that, the interaction of the two factors (strip size of water harvesting system x mineral nitrogen and biofertilization) was significant for total chlorophyll with both growth stages (56 and 70 DAS) during the first and second successive seasons.

Results presented in Table (15) revealed the effect of interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) on total chlorophyll with the different growth stages of barley grown in 2011/2012 and 2012/2013 growing seasons.

It was noticed that, the interaction treatment ((4: 1) ratio with the mineral nitrogen at a rate of 20 kg/fed. + biofertilization) recorded the highest mean values of total chlorophyll (40.70 and 41.62 %) at the two growth stages (56 and 70 DAS) respectively, during the first season. During the second season, the same trend was obtained, which were (40.28 and 41.56 %) at the two growth stages (56 and 70 DAS), respectively. On the other side, lowest mean values (31.88 and 33.24 %) at (56 and 70 DAS) respectively, during the first season and (31.80 and 32.99 %) at the same stages (56 and 70 DAS) respectively, during the second season were recorded by the interaction treatment (without leaving catchment area in without mineral nitrogen and biofertilization).

Generally, the effect of catchments area system as a type of micro catchments water harvesting can improve soil moisture storage prolong the period of moisture availability and enhance plant growth **(Singh and Bhan, 1998).**

From the previous results which were mentioned before we can conclude that:
1- The catchment area participated to save more water for cultivated area which caused direct increases in all the studies characters.
2- The increasing percentages were in relati**o**nship with increasing the catchment area.
3- The direct rainfall was not enough to obtain suitable values with respect to the growth of barley plant.

4.2. Yield, Yield Components and Water Use Efficiency:

4.2.1. Number of tillers/m^2:

Data of the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of tillers per square meter at harvest time of barley grown during 2011/2012 and 2012/2013 experimental seasons were presented in Table (16).

Data presented in Table (16) revealed the subjected barley plants to strip size of water harvesting system. For the second season, (4:1) ratio gave higher number of tillers/m^2 (145.52/m^2) while, the lowest number (141.09/m^2) was recorded by without leaving catchment area treatment.

Table (16): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on number of tillers/m^2 and spike length (cm) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	N. of tillers/m^2		Spike length (cm)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	163.48	141.09	12.88	12.73
1 : 1	164.91	142.21	13.63	13.25
2 : 1	165.91	143.25	14.33	13.92
3 : 1	167.09	144.27	15.02	14.49
4 : 1	167.42	145.52	15.64	15.28
New L.S.D. $_{0.05}$	N.S	2.93	0.148	0.143
Fertilization (B):				
Without fertilization	157.45	135.56	13.42	12.93
10 Kg N/fed.	166.02	143.07	14.51	13.97
20 Kg N/fed.	171.34	147.64	14.74	14.19
Microbein	160.43	140.06	13.77	14.01
10 Kg N/fed.+ Microbein	167.02	144.33	14.57	14.12
20 Kg N/fed.+ Microbein	172.29	148.96	14.78	14.37
New L.S.D. $_{0.05}$	2.99	2.26	0.184	0.177
Interaction:				
AXB	6.55	4.97	0.409	0.391

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

As for strip size of water harvesting system effects during the second season, data indicated that, number of tillers of barley plants increased by about 0.79, 1.53, 2.25 and 3.14 % as compared with the control due to using (1: 1), (2: 1), (3: 1) and (4: 1) strip size of water harvesting system treatments over the control treatment (without leaving catchment area), respectively.

Data in Table (16) indicated that, mineral nitrogen and biofertilization significantly increased the number of tillers/m^2. During the first and second seasons, respectively, the highest mean values (172.29 and 148.96 tillers/m^2) were optioned by applying 20 kg N/fed. with biofertilization treatment. On the other side, the lowest mean values (157.45 and 135.56 tillers/m^2) were recorded by using control treatment (without mineral nitrogen and biofertilization) during the two seasons, respectively.

The increase in the number of tillers/m^2 may be due to the increase in the percentage of germination as a results of N application, and better utilization of soil moisture during germination **(Panda *et al.*, 1988)**, also the increase in the number of tillers/m^2 may be due to the role of microorganisms activity for phytohormones formation and translocation to the plant, especially (IAA, CK_S and GA_S), which play an important task in break of plant apical dominance and encourage new tillers formation, also its important role in increasing photosynthesis rate. These results agree with those of **Attia, (2005)** as well as **Tarun, (2013)** who showed that, N fertilizer at a rate of 80 kg/ha with both (*Azotobacter+Azospirillum*) inoculations was found to be the most responsive, with significant increase in the maximum number of tillers/m^2 of barley.

Data in Table (17) showed the effect of the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of tillers/m^2 at harvest time of barley grown during 2011/2012 and 2012/2013 seasons. The interaction treatment ((4: 1) with the mineral nitrogen at a rate of 20 kg/fed. + biofertilization) gave the highest number of tillers/m^2 (171.31and 150.36 tillers/m^2) during the first and second seasons, respectively, while, the lowest number (148.27 and 128.10 tillers/m^2) during the two seasons respectively, were given by the interaction treatment (without leaving catchment area and without mineral nitrogen and biofertilization) as compared with the other strip size of water harvesting system. Similar findings were pointed out by **Panda *et al.*, (1988).**

4.2.2. Spike length (cm):

The results in Table (16) showed the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on spike length (cm) at harvest time of barley grown during 2011/2012 and 2012/2013 growing seasons.

Regarding the effect of strip size of water harvesting system on spike length, results showed that, this character was significantly affected by the strip size of water harvesting system. Maximum mean values (15.64 and 15.28 cm) during the first and second seasons respectively, were obtained by using the largest catchment area (144 m^2). On the other hand, minimum mean values (12.88 and 12.73 cm) during the two seasons respectively, were obtained from (without leaving catchment area). Similar findings were pointed out from **Abd El-Aleem, *et al.*, (1992), Hassan *et al.*, (1998)** and **Attia, (2005)**.

Table (17): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on number of tillers/m^2 and spike length (cm) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		N. of tillers/m^2		Spike length (cm)	
		11/12	12/13	11/12	12/13
Control:					
	Without fertilization	148.27	128.10	11.98	11.70
	10 Kg N/fed.	162.03	139.93	13.08	12.76
	20 Kg N/fed.	170.31	148.35	13.21	12.88
	Microbein	155.69	136.28	12.76	13.20
	10 Kg N/fed.+ Microbein	165.16	142.63	13.05	12.82
	20 Kg N/fed.+ Microbein	174.42	148.26	13.19	13.01
(1 : 1):					
	Without fertilization	157.20	134.89	13.05	12.53
	10 Kg N/fed.	164.72	141.36	13.77	13.22
	20 Kg N/fed.	170.37	146.22	13.95	13.39
	Microbein	158.36	137.69	13.21	13.43
	10 Kg N/fed.+ Microbein	164.17	143.88	13.81	13.36
	20 Kg N/fed.+ Microbein	174.65	149.23	13.96	13.55
(2 : 1):					
	Without fertilization	158.03	135.90	13.59	13.04
	10 Kg N/fed.	165.12	142.00	14.52	13.94
	20 Kg N/fed.	171.91	147.84	14.74	14.15
	Microbein	164.14	142.96	13.74	13.94
	10 Kg N/fed.+ Microbein	166.38	143.09	14.57	14.08
	20 Kg N/fed.+ Microbein	169.87	147.73	14.82	14.38
(3 : 1):					
	Without fertilization	161.25	138.68	14.03	13.37
	10 Kg N/fed.	168.55	144.95	15.26	14.55
	20 Kg N/fed.	169.58	145.84	15.54	14.82
	Microbein	162.25	141.34	14.28	14.36
	10 Kg N/fed.+ Microbein	169.68	145.59	15.34	14.73
	20 Kg N/fed.+ Microbein	171.20	149.20	15.67	15.09
(4 : 1):					
	Without fertilization	162.51	140.23	14.48	14.00
	10 Kg N/fed.	169.71	147.09	15.94	15.41
	20 Kg N/fed.	170.35	146.95	16.26	15.71
	Microbein	161.73	142.03	14.86	15.12
	10 Kg N/fed.+ Microbein	169.72	146.44	16.07	15.63
	20 Kg N/fed.+ Microbein	171.31	150.36	16.24	15.84
New L.S.D. $_{0.05}$		6.55	4.97	0.409	0.391

Control: Without catchment area.

Concerning mineral nitrogen and biofertilization, data in Table (16) indicated that, mineral nitrogen and biofertilization had slightly significant effect on spike length (cm). Maximum mean values (14.78 and 14.37 cm) during first and second season respectively, were obtained by using the highest dose of mineral nitrogen with biofertilization (20 kg N/fed.+ biofertilization) while, the minimum mean values (13.42 and 12.93 cm) during the two seasons respectively, were obtained by using the control treatment (without mineral nitrogen and biofertilization). In this respect **Attia, (2005)** reported that, spike length was significantly affected by mineral and bio-fertilization.

The effects of the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on spike length (cm) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons were presented in Table (17).

Results showed a significant effect on spike length by this interaction. Maximum mean value (16.26 cm) during the first season was obtained by catchment area ratio 4: 1 and 20 kg N/fed. without biofertilization. While, for the second season, maximum mean value (15.84 cm) was detected by catchment area ratio 4: 1 and 20 kg N/fed. with biofertilization. Minimum mean values (11.98 and 11.70 cm) were recorded by the interaction treatment (without leaving catchment area and without (mineral nitrogen and biofertilization)) during the two seasons, respectively.

4.2.3. Number of spikes/m^2:

The analysis of variance of the obtained data presented in Table (18) showed the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of spikes per square meter at harvest time of barley grown during 2011/2012 and 2012/2013 growing seasons.

Concerning strip size of water harvesting system effect, the largest strip size of water harvesting system (144 m^2) gave the maximum number of spikes/m^2 (141.26 and 116.98 spikes/m^2) during the first and second seasons respectively, while the lowest number (130.63 and 107.47 spikes/m^2) during the two seasons respectively, were obtained by without leaving catchment area as compared with the other strip size of water harvesting system during both seasons. These results agree with those of **Hassan *et al.*, (1998)** and **Attia, (2005)** who found that, number of spikes/m^2 increased with increasing the ratio between contributed area and cultivated area.

Data in Table (18) indicated that, number of spikes/m^2 increased significantly by increasing the rate of mineral nitrogen with biofertilization. The heights number of spikes/m^2 (142.74 and 117.73 spikes/m^2) during the two growing seasons respectively, were obtained by applying 20 kg N/fed. with biofertilization, but the lowest number (127.77and 104.67 spikes/m^2) were recorded by control treatment (without mineral nitrogen and biofertilization) during the two seasons respectively. These results are in line with those reported by **Gomma, (1992)** who reported that, the high mineral nitrogen levels improved barley spikes number per square meter.

The effect of the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of spikes/m^2 at harvest time of barley grown in 2011/2012 and 2012/2013 seasons was presented in Table (19).

Table (18): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on number of spikes/m^2 and number of spikelets/spike at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	N. of spikes/m^2		N. of spikelets /spike	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	130.63	107.47	12.22	11.69
1 : 1	133.82	110.08	12.40	11.83
2 : 1	136.49	112.26	12.49	11.92
3 : 1	139.31	114.57	12.59	12.01
4 : 1	141.26	116.98	12.68	12.07
New L.S.D. $_{0.05}$	2.90	2.36	N.S	N.S
Fertilization (B):				
Without fertilization	127.77	104.67	12.23	11.63
10 Kg N/fed.	136.48	111.79	12.54	11.92
20 Kg N/fed.	141.57	115.96	12.62	11.98
Microbein	131.63	109.61	12.22	11.71
10 Kg N/fed.+ Microbein	137.62	113.89	12.58	12.05
20 Kg N/fed.+ Microbein	142.74	117.73	12.67	12.13
New L.S.D. $_{0.05}$	2.42	1.98	N.S	N.S
Interaction:				
AXB	5.34	4.37	0.90	0.86

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (19): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on number of spikes/m^2 and number of spikelets/spike at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	N. of spikes/m^2		N. of spikelets/ spike	
	11/12	12/13	11/12	12/13
Control:				
Without fertilization	116.66	95.42	11.74	11.19
10 Kg N/fed.	129.48	105.90	12.34	11.76
20 Kg N/fed.	140.72	115.09	12.46	11.87
Microbein	124.47	103.58	12.10	11.62
10 Kg N/fed.+ Microbein	132.21	109.30	12.28	11.79
20 Kg N/fed.+ Microbein	140.27	115.55	12.40	11.91
(1 : 1):				
Without fertilization	125.90	102.97	12.27	11.65
10 Kg N/fed.	133.66	109.32	12.59	11.96
20 Kg N/fed.	138.94	113.64	12.55	11.92
Microbein	128.12	106.57	11.88	11.38
10 Kg N/fed.+ Microbein	133.52	110.38	12.53	12.00
20 Kg N/fed.+ Microbein	142.76	117.58	12.60	12.07
(2 : 1):				
Without fertilization	128.31	104.95	12.28	11.66
10 Kg N/fed.	135.70	110.99	12.46	11.84
20 Kg N/fed.	142.07	116.20	12.61	11.98
Microbein	134.98	112.18	12.30	11.79
10 Kg N/fed.+ Microbein	137.07	113.28	12.62	12.09
20 Kg N/fed.+ Microbein	140.81	115.98	12.67	12.13
(3 : 1):				
Without fertilization	132.68	108.52	12.35	11.73
10 Kg N/fed.	140.46	114.88	12.71	12.07
20 Kg N/fed.	142.24	116.34	12.74	12.10
Microbein	134.65	111.91	12.35	11.83
10 Kg N/fed.+ Microbein	141.78	117.13	12.64	12.11
20 Kg N/fed.+ Microbein	144.03	118.62	12.73	12.20
(4 : 1):				
Without fertilization	135.29	111.47	12.54	11.89
10 Kg N/fed.	143.11	117.87	12.61	11.96
20 Kg N/fed.	143.89	118.50	12.72	12.01
Microbein	135.93	113.78	12.46	11.92
10 Kg N/fed.+ Microbein	143.50	119.36	12.82	12.26
20 Kg N/fed.+ Microbein	145.83	120.91	12.92	12.36
New L.S.D. $_{0.05}$	5.34	4.37	0.90	0.86

Control: Without catchment area.

It was noticed that, for both seasons, the interaction treatment (144 m^2 with 20 kg N/fed. + biofertilization) recorded the highest number of spikes/m^2 (145.83 and 120.91 spikes/m^2) during the two seasons respectively, on the other side the lowest number (116.66 and 95.42 spikes/m^2) during the first and second seasons, respectively, were recorded by without leaving catchment area in without (mineral nitrogen and biofertilization) as compared with the other strip size of water harvesting system in the other treatments. These results were in line with those obtained from **Singh and Bhan, (1998)** whose found that, No. of spikes/m row was favorably affected by increasing water supply and nitrogen levels. **Karczmarczyk *et al.*, (1997)** reported the same findings.

4.2.4. Number of spikeletes/spike:

The effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of spikeletes/spike at harvest time of barley grown during 2011/2012 and 2012/2013 experimental seasons were presented in Table (18). Number of spikeletes/spike was not affected by strip size of water harvesting system and (mineral nitrogen and biofertilization) under this study for both seasons. Opposite results were recorded by **Attia, (2005)** who found that, the number of spikeletes/spike was significantly increased by increasing the ratio between contributed area and cultivated area.

The interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of spikeletes/spike at harvest time of barley grown in 2011/2012 and 2012/2013 seasons was investigated. Data presented in Table (19) showed that such interaction had a significant effect on number of spikeletes/spike. Maximum number of spikeletes/pike (12.92 and 12.36 spikeletes/spike) during the first and second seasons respectively, were obtained by the interaction treatment ((4: 1) ratio and 20 kg N/fed. with biofertilization), while minimum number (11.74 and 11.19 spikeletes/spike) during the two seasons respectively, were recorded by without leaving catchment area in without (mineral nitrogen and biofertilization) treatment.

4.2.5. Number of grains/spike:

Results presented in Table (20) revealed the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on number of grains/spike at harvest time of barley grown during 2011/2012 and 2012/2013 growing seasons.

During the two seasons respectively, the largest catchment area (144 m^2) gave the highest number of grains per spike (35.91 and 34.06 grains/spike) compared to the other strip sizes of water harvesting system. On the other side, the lowest number of grains per spike (32.52 and 30.84 grains/spike) was recorded by without leaving catchment area during the two growing seasons, respectively. These results agree with those of **Hassan *et al.*, (1998)** as well as **Attia, (2005)** who pointed out that, increasing the ratio between catchment and cultivated area significantly increased the number of grains per spike.

Regarding the role of mineral nitrogen and biofertilization, data in Table (20) indicated that, mineral nitrogen and biofertilization had a significant effect on the number of grains/spike. The highest number of grains/spike (35.59 and 33.85 grains/spike) during the first and the second seasons respectively, were obtained by applying 20 kg N/fed. with biofertilization, while the lowest number (32.92 and 31.12 grains/spike) were achieved by control treatment (without mineral nitrogen and biofertilization) during

Table (20): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on number of grains/spike and 1000 grain weight (gm) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	N. of grains/spike		1000 grain weight (gm)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	32.52	30.84	30.78	27.42
1 : 1	33.94	32.19	34.61	30.83
2 : 1	34.44	32.66	37.31	33.24
3 : 1	35.10	33.28	39.21	34.93
4 : 1	35.91	34.06	40.74	36.29
New L.S.D. $_{0.05}$	1.30	1.23	1.14	1.02
Fertilization (B):				
Without fertilization	32.92	31.12	33.25	29.62
10 Kg N/fed.	34.29	32.42	36.52	32.53
20 Kg N/fed.	35.20	33.28	38.59	34.38
Microbein	33.82	32.17	34.18	30.45
10 Kg N/fed.+ Microbein	34.46	32.78	37.26	33.19
20 Kg N/fed.+ Microbein	35.59	33.85	39.40	35.10
New L.S.D. $_{0.05}$	0.63	0.59	0.58	0.52
Interaction:				
AXB	1.36	1.28	1.30	1.16

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

the two growing seasons, respectively. These results are agreement with those found by **Gomma, (1992)** who reported that, the high mineral nitrogen levels improved the number of grains/spike of barley. Also, **Attia, (2005)** reported that, mineral and biofertilization treatments had a significant effect on the number of grains/spike.

Data reported in Table (21) indicated the effect of the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on the number of grains/spike at harvest time of barley grown during 2011/2012 and 2012/2013 growing seasons.

The interaction treatment ((4: 1) with 20 kg N/fed. + biofertilization) obtained the highest number of grains/spike (37.46 and 35.62 grains/spike) during the two seasons respectively, while the lowest number (30.97 and 29.28 grains/spike) were recorded from without leaving catchment area in control treatment of mineral nitrogen and biofertilization during the two seasons, respectively.

4.2.6.1000 grain weight (g):

The analysis of variance for this trait showed that, there were significant differences for the effects of the two studied factors on 1000 grain weight (g) during 2011/2012 and 2012/2013 seasons as shown in Table (20).

As for the strip size of water harvesting system effects, (4: 1) ratio significantly exceeded the other ratios between the catchment and cultivated area during both growing seasons. The mean values of 1000-grain weight, as average were (34.61, 37.31, 39.21, 40.74 and 30.78 gm) during the first season and were (30.83, 33.24, 34.93, 36.29 and 27.42 gm) during the second season for (1: 1), (2: 1), (3: 1), (4: 1) and without leaving catchment area respectively, as shown in Table (20).

A mature seed has four components significant both physiologically and ecologically. These features also provide the seed with protective mechanism to withstand harsh environments, while in a quiescent state **(Gardner *et al.,* 1985)**. Similar findings were obtained by **Attia, (2005)** who reported that, increasing the ratio between contributed to cultivated area caused an increase in 1000 grain weight. Also, **Xiao and Dong, (2002)** reported that 120: 60 cm ridge and furrow (120 cm wide ridge and 60 cm wide furrow) system increased 1000 grain weight by 4.7% compared with 60: 60 cm ridge and furrow (60 cm wide ridge and 60 cm wide furrow) system. Same findings were recorded by **Hassan *et al.*, (1998)**.

With regard to the mean values of 1000-grain weight, it was affected by mineral nitrogen and biofertilization during the first and second growing seasons as shown in Table (20). The highest mean values (39.40 and 35.10 gm) of 1000-grain weight during the first and the second seasons, respectively were obtained by using 20 kg N/fed. with biofertilization. On the other hand, the lowest mean values (33.25 and 29.62 gm) during the two seasons respectively, were recorded by control treatment (without mineral nitrogen and biofertilization). It could be concluded that, mineral nitrogen caused a significant increase in 1000-grain weight. This may be due to protein accumulation and cell division, which led to an increase in 1000-grain weight. Similar results were optioned by **Gomma, (1992). Also, Bashirzadeh *et al.*, (2012)** pointed out that, the maximum seed weight was

Table (21): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on number of grains/spike and 1000 grain weight (gm) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		N. of grains/spike		1000 grain weight (gm)	
		11/12	12/13	11/12	12/13
Control:					
	Without fertilization	30.97	29.28	28.75	25.61
	10 Kg N/fed.	32.53	30.76	30.77	27.41
	20 Kg N/fed.	33.16	31.35	31.32	27.90
	Microbein	32.15	30.60	29.51	26.29
	10 Kg N/fed.+ Microbein	32.67	31.09	31.24	27.83
	20 Kg N/fed.+ Microbein	33.62	31.98	33.10	29.49
(1 : 1):					
	Without fertilization	32.58	30.80	31.39	27.96
	10 Kg N/fed.	33.98	32.12	34.25	30.52
	20 Kg N/fed.	34.84	32.94	36.40	32.43
	Microbein	33.16	31.56	33.55	29.89
	10 Kg N/fed.+ Microbein	34.14	32.48	35.25	31.40
	20 Kg N/fed.+ Microbein	34.93	33.22	36.81	32.80
(2 : 1):					
	Without fertilization	33.16	31.35	33.80	30.11
	10 Kg N/fed.	34.36	32.49	37.63	33.53
	20 Kg N/fed.	34.79	32.90	39.94	35.58
	Microbein	33.72	32.08	33.83	30.14
	10 Kg N/fed.+ Microbein	34.59	32.91	38.18	34.01
	20 Kg N/fed.+ Microbein	35.99	34.23	40.50	36.08
(3 : 1):					
	Without fertilization	33.88	32.03	34.97	31.15
	10 Kg N/fed.	35.06	33.15	39.02	34.77
	20 Kg N/fed.	35.81	33.85	42.26	37.65
	Microbein	35.11	33.40	35.93	32.01
	10 Kg N/fed.+ Microbein	34.75	33.06	40.28	35.88
	20 Kg N/fed.+ Microbein	35.97	34.21	42.82	38.14
(4 : 1):					
	Without fertilization	34.01	32.16	37.34	33.27
	10 Kg N/fed.	35.53	33.59	40.90	36.44
	20 Kg N/fed.	37.39	35.35	43.03	38.33
	Microbein	34.93	33.23	38.06	33.91
	10 Kg N/fed.+ Microbein	36.15	34.38	41.33	36.82
	20 Kg N/fed.+ Microbein	37.46	35.62	43.78	39.00
New L.S.D. $_{0.05}$		1.36	1.28	1.30	1.16

Control: Without catchment area.

observed with *Azospirillum lipoferum* inoculation and the highest mineral nitrogen level, and the minimum was obtained by without inoculation and without mineral nitrogen application.

Concerning the interaction, from data presented in Table (21), it could be observed that, the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) was significant differences for 1000-grain weight during 2011/2012 and 2012/2013 seasons. These results are accordance with those from **Karczmarczyk *et al.*, (1997)** as well as **Singh** and **Bhan, (1998)**.

4.2.7. Grain yield (kg/fed.):

Data in Table (22) showed the response of barley yield to the different strip size of water harvesting system and (mineral nitrogen and biofertilization). The mean of this trait given in Table (22) showed that, the largest strip size of water harvest system (4: 1) ratio tended to out yield the four strip size of water harvest system as an average (856.32 and 628.74 kg/fed.) during the first and second seasons respectively, while without leaving catchment area treatment recorded the lowest grain yield (544.11 and 395.29 kg/fed.) respectively, during both seasons. These results agree with those of **Abd El-Aleem *et al.*, (1992)** as well as **Hassan *et al.*, (1998)** and **Attia, (2005)** who found that, grain yield was significantly increased with increasing the ratios of contributed (catchment) area to cultivated area as compared with control. In this respect, also **Prinz and Singh, (2000)** reported that, the potential to improve agricultural yields depends strongly on rainfall pattern and its distribution.

The tabulated results in Table (22) demonstrated that, applying mineral nitrogen and biofertilization had a significant effect on grain yield kg/fed. during the two growing seasons. Maximum mean values (833.61 and 605.23 kg/fed.) during the first and second seasons respectively, were obtained when plants received the height dose of mineral nitrogen with biofertilization (20 kg N/fed. with biofertilization) while, minimum mean values (589.77 and 418.67 kg/fed.) were obtained by control treatment (without mineral nitrogen and biofertilization) during both seasons, respectively. It could be concluded that, biofertilization promote the production of barley grains. Once roots emerge at seed germination and are colonized by N2- fixing bacteria, energetic pathways such as glycolysis and conversion of conjugate IAA to active IAA are stimulated. Also, the mineral nitrogen fixing bacteria may increase the synthesis of the endogenous phytohormones i. e. indole acetic acid (IAA), Gibbrelic acids (GAS) and cytokinones (CKS) which plays an important role in formation of a big active root system, that allow more nutrients uptake and hence may promote photosynthesis and translocation as well as accumulation of dry matter within different plants parts and hence increased number of spikes/m^2 and number of grains/spike. In this respect, **EL-Khawas, (1990)** and **Ishac *et al.*, (1984)** reported that, inoculating grains with *Azospirillum brasilense* significantly increased barley grain yield. **Gomma, (1992)** pointed out that, the high mineral nitrogen levels improved barley grain yield. Also, **Bashirzadeh *et al.*, (2012)** illustrated that, the maximum seed yield of barley was observed with *Azospirillum lipoferum* inoculation and highest mineral nitrogen level, and the minimum was obtained by non-inoculation and without mineral nitrogen application. These results were in harmony with those obtained by **Barsoum, (1994)** who found that, application of 80 kg N / fed. gave the highest barley yield and yield components. **Also, Berhanu, (2013)** reported that, highest grain yield

Table (22): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on grain yield (kg/fed.) and straw yield (kg/fed.) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	Grain yield (kg/fed.)		Straw yield (kg/fed.)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	544.11	395.29	1280	1044
1 : 1	648.19	470.77	1376	1128
2 : 1	720.23	523.77	1494	1225
3 : 1	788.72	575.73	1591	1304
4 : 1	856.32	628.74	1708	1390
New L.S.D. $_{0.05}$	5.48	11.85	17.80	14.90
Fertilization (B):				
Without fertilization	589.77	418.67	1378	1127
10 Kg N/fed.	697.72	511.80	1474	1206
20 Kg N/fed.	802.85	572.98	1569	1284
Microbein	617.66	467.43	1421	1159
10 Kg N/fed.+ Microbein	727.48	537.05	1497	1224
20 Kg N/fed.+ Microbein	833.61	605.23	1599	1309
New L.S.D. $_{0.05}$	4.08	6.74	14.40	11.80
Interaction:				
AXB	9.15	15.10	32.16	26.36

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

(103%) of barley (*Hordeum vulgare* L.) was obtained with 120 kg N/ha. compared with the control. **Also, Azimi *et al.*, (2013)** found that application of biofertilizer, gave the highest grain barley yield (7.6 ton/ha) and non-application of biofertilizers treatment gave the lowest grain yield (6.3 ton/ha). **Tarun, (2013)** showed that, fertilizer N at a rate of 80 kg/ha with both (*Azotobacter+Azospirillum*) inoculations were found to be the most responsive, with significantly increased grain yield of barley.

The interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) on grain yield (kg/fed.) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons was shown in Table (23).

Data indicated that, the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) was significant during the two growing seasons. For both seasons respectively, the highest mean values of grain yield (993.51 and 726.40 kg/fed.) were detected by using the interaction treatment ((4: 1) ratio with 20 kg N/fed. + biofertilization). On the other hand, the lowest mean values (436.74 and 309.12 kg/fed.) during the two seasons, respectively were obtained by the interaction treatment (without leaving catchment area and without mineral nitrogen and biofertilization). These results may **be** due to the application of N favored relatively more moisture extraction due to higher grain yield. The amount fertilizer and the barley yield were parabolic when the amount of water supply was constant, the amount of mineral nitrogen and water content at a positively alternative effect. Fertilizer application can improve barley efficiency and increase barley yield. In the rainfed conditions the amount of increase in barley yield by fertilizer can be arranged as follow: with rainfall yield larger than year with minimum rainfall larger than with low rainfall. The maintained results may be due to the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on barley is important to produce constant and economically attractive yield. These results were in harmony with those obtained by **Singh and Bhan, (1998)** who found that, grain yield weight was favorably affected by increasing water supply and nitrogen levels.

The increase in grain yield is due to increase in number of grains/spike, weight of grains/spike, number of spikes/m^2, 1000-grain weight, flag leaf area, total dry mater and maturity.

4.2.8. Straw yield (kg/fed.):

In this respect, data presented in Table (22) indicated the effect of strip size of water harvesting system and (mineral nitrogen and biofertilization) on straw yield (kg/fed.) at harvest time of barley grown during 2011/2012 and 2012/2013 successive seasons.

This character was significantly affected by the size of strip water harvesting system during both seasons. The largest size of strip water harvesting system (144 m^2) gave the highest mean values of straw yield (1708 and 1390 kg/fed) during the first and second seasons respectively, while the lowest mean values (1280 and 1044 kg/fed.) during the two seasons respectively, were obtained by without leaving catchment area. In this respect, **Hassan *et al.*, (1998)** and **Attia, (2005)** found the similar results.

Table (23): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on grain yield (kg/fed.) and straw yield (kg/fed.) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		Grain yield (kg/fed.)		Straw yield (kg/fed.)	
		11/12	12/13	11/12	12/13
Control:					
	Without fertilization	436.74	309.12	1126	919
	10 Kg N/fed.	522.43	386.76	1239	1012
	20 Kg N/fed.	609.63	434.35	1372	1121
	Microbein	489.20	361.64	1236	1002
	10 Kg N/fed.+ Microbein	557.31	408.94	1282	1047
	20 Kg N/fed.+ Microbein	649.32	470.92	1426	1165
(1 : 1):					
	Without fertilization	544.45	379.59	1316	1079
	10 Kg N/fed.	631.28	459.94	1365	1119
	20 Kg N/fed.	728.97	519.54	1452	1191
	Microbein	566.82	433.64	1320	1079
	10 Kg N/fed.+ Microbein	659.68	482.25	1336	1095
	20 Kg N/fed.+ Microbein	757.93	549.64	1469	1204
(2 : 1):					
	Without fertilization	598.55	422.53	1393	1143
	10 Kg N/fed.	710.43	517.05	1474	1209
	20 Kg N/fed.	819.21	580.24	1593	1306
	Microbein	615.87	467.67	1411	1155
	10 Kg N/fed.+ Microbein	733.66	542.08	1490	1222
	20 Kg N/fed.+ Microbein	843.68	613.05	1605	1316
(3 : 1):					
	Without fertilization	657.25	465.99	1468	1204
	10 Kg N/fed.	774.54	570.40	1585	1300
	20 Kg N/fed.	892.98	637.07	1666	1366
	Microbein	674.80	516.73	1503	1231
	10 Kg N/fed.+ Microbein	809.14	598.07	1627	1334
	20 Kg N/fed.+ Microbein	923.62	666.15	1694	1389
(4 : 1):					
	Without fertilization	711.87	516.13	1588	1292
	10 Kg N/fed.	849.91	624.85	1708	1390
	20 Kg N/fed.	963.44	693.69	1763	1436
	Microbein	741.59	557.46	1636	1328
	10 Kg N/fed.+ Microbein	877.60	653.89	1748	1424
	20 Kg N/fed.+ Microbein	993.51	726.40	1803	1468
New L.S.D. $_{0.05}$		9.15	15.10	32.16	26.36

Control: Without catchment area.

The straw yield increased significantly by applying mineral nitrogen and biofertilization, the highest dose of mineral nitrogen with biofertilization (20 kg N/fed. with biofertilization) increased straw yield (1599 and 1309 kg/fed.) during the first and second seasons respectively. The lowest straw yield (1378 and 1127 kg/fed.) was obtained by control treatment (without mineral nitrogen and biofertilization) during the two seasons, respectively. These results were in harmony with those obtained by **Barsoum, (1994)** and **Kumawat and Jat, (2005)**.

Concerning the interaction between the strip size of water harvesting system and (mineral nitrogen and biofertilization) on straw yield (kg/fed.) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons, there was a significant affect for straw yield by this interaction during the two seasons as shown in Table (23). The interaction treatment (144 m^2) with 20 kg N/fed. + biofertilization) recorded the highest mean values of straw yield (1803 and 1468 kg/fed.) during the first and second seasons respectively. Lowest values (1126 and 919 kg/fed.) during the two seasons respectively, were obtained by the interaction treatment (without leaving catchment area in without mineral nitrogen and biofertilization).

4.2.9. Biological yield (kg/fed.):

The trend of biological yield (kg/fed.) behaved the same as of straw yield as affected by strip size of water harvesting system and (mineral nitrogen and biofertilization) as shown in Table (24).

Results illustrated that, strip size of water harvesting system were significantly differed for biological yield during both seasons. Biological yield for without leaving catchment area, (1: 1), (2: 1), (3: 1), and (4: 1) ratio were 1824, 2024, 2215, 2379 and 2564 kg/fed. respectively, during the first season and were 1440, 1599, 1749, 1880 and 2018 kg/fed. respectively, during the second season. Similar results accordance with those from **Verma and Sarma, 1990)** and **Abelardo, (1996)** as well as **Hassan *et al.*, (1998)** and **Attia, (2005)**.

The increase in biological yield was due to the increase in crop growth rate (CGR), higher crop growth rate with liberal irrigation could be due to beneficial effect of water on cell turgidity and cell elongation. The results confirms to findings of **Singh (1977)**.

Data in Table (24) indicated that subjecting plants to mineral nitrogen and biofertilization caused a significant effect on biological yield during both growing seasons. During the first and second seasons respectively, maximum biological yield (2433 and 1914 kg/fed.), were detected when plants received the highest dose of mineral nitrogen with biofertilization (20 kg N/fed. with biofertilization). On the other hand, the control treatment (without mineral nitrogen and biofertilization) recorded the lowest mean values (1968 and 1546 kg/fed.) during the two seasons, respectively. Similar results were obtained by **El-sayed *et al.*, (1999)** who found that, the biofertilizer (*nitrobein* and *cerealin*) caused an increase in grain yield about (32.6 % for biofertilization), (14.0 % for *nitrobein*) and (19.3 % for *cerrealine*) compared to the uninoculation.

Data in Table (25) indicated that, the interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) on biological yield (kg/fed.)

Table (24): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on biological yield (kg/fed.) and harvest index (%) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	Biological yield (kg/fed.)		Harvest index (%)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	1824	1440	29.72	27.36
1 : 1	2024	1599	31.91	29.35
2 : 1	2215	1749	32.40	29.84
3 : 1	2379	1880	33.03	30.53
4 : 1	2564	2018	33.28	31.04
New L.S.D. $_{0.05}$	21.93	23.40	0.20	0.39
Fertilization (B):				
Without fertilization	1968	1546	29.84	26.94
10 Kg N/fed.	2172	1718	31.97	29.65
20 Kg N/fed.	2372	1857	33.67	30.68
Microbein	2039	1626	30.19	28.63
10 Kg N/fed.+ Microbein	2224	1761	32.60	30.36
20 Kg N/fed.+ Microbein	2433	1914	34.12	31.48
New L.S.D. $_{0.05}$	16.35	13.48	0.20	0.32
Interaction:				
AXB	36.59	30.16	0.46	0.71

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

was significant during the two growing seasons, whereas the highest values were obtained by using the largest strip size of water harvesting system (4: 1) with the highest dose of mineral nitrogen and biofertilization (20 kg N/fed. with biofertilization) while, the lowest values were detected by without leaving catchment area in without (mineral nitrogen and biofertilization) for both successive seasons.

The increasing in biological yield of barley may be due to the increase in grain and straw yield, fresh and dry weight of leaves and stem.

4.2.10. Harvest index (%):

Harvest index % is a biological criteria which defined as the ratio between grain yield and biological yield also, it is considered as measure of the partitioning process of the dry matter accumulated over the growth season between vegetative organs of the plant and grains. Data presented in Table (24) showed that, the mean values of harvest index % differed significantly during the two growing seasons as affected by the strip size of water harvesting system.

During the two seasons, it could be noticed that, the largest strip size of water harvesting system (4: 1) surpassed the other four sizes strip of water harvesting system for this character. The averages of harvest index for the four strip sizes of water harvesting system (without catchment area), (1: 1), (2: 1), (3: 1) and (4: 1) were (29.72, 31.91, 32.40, 33.03 and 33.28 %) respectively, during the first season and were (27.36, 29.35, 29.84, 30.53 and 31.04 %) respectively, during the second one. In this respect, **Riki *et al.,* (1996)** found that, the harvest index under rainfed conditions was 108 % than under irrigated conditions. Similar findings were recorded by **Hassan *et al.,* (1998)**, **Shaozhong *et al.,* (2002) and Attia, (2005).**

Harvest index % as affected by mineral nitrogen and biofertilization were presented in Table (24). Mineral nitrogen and biofertilization had remarkably affected this character during both growing seasons. The highest mean values (34.12 and 31.48 %) were detected by using the highest dose of mineral nitrogen with biofertilization (20 kg N/fed. with biofertilization) during the two growing seasons, respectively. The lowest mean values (29.84 and 26.94 %) during the two seasons respectively, were obtained by without mineral nitrogen and biofertilization. Similar results were pointed out from **El-Sayed *et al.*, (1999)** who found that, the biofertilizer (biofertilization, *Nitrobein* and *Cerealin*) caused an increase in harvest index of barley reached about (62.8% for biofertilization), (40.3% for *nitrobein*) and (19.7% for *cerrealine*) compared with the noninoculation.

The interaction effect between strip size of water harvesting system and biofertilization on harvest index % was significant as shown in Table (25) during the two growing seasons. Maximum mean values of harvest index % (35.53 and 33.10 %) during the two seasons respectively, were obtained by the interaction treatment ((4: 1) with 20 kg N/fed. + biofertilization). While, for both seasons respectively, minimum values (27.95 and 25.17 %) were achieved by the interaction treatment (without leaving catchment area in without mineral nitrogen and biofertilization).

Table (25): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on biological yield (kg/fed.) and harvest index (%) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		Biological yield (kg/fed.)		Harvest index (%)	
		11/12	12/13	11/12	12/13
Control:					
	Without fertilization	1563	1228	27.95	25.17
	10 Kg N/fed.	1761	1398	29.66	27.66
	20 Kg N/fed.	1982	1556	30.76	27.92
	Microbein	1725	1364	28.35	26.52
	10 Kg N/fed.+ Microbein	1839	1456	30.31	28.09
	20 Kg N/fed.+ Microbein	2075	1636	31.29	28.79
(1 : 1):					
	Without fertilization	1861	1459	29.26	26.02
	10 Kg N/fed.	1996	1579	31.62	29.12
	20 Kg N/fed.	2181	1710	33.42	30.38
	Microbein	1887	1513	30.04	28.66
	10 Kg N/fed.+ Microbein	1995	1577	33.06	30.57
	20 Kg N/fed.+ Microbein	2227	1754	34.04	31.34
(2 : 1):					
	Without fertilization	1992	1565	30.05	27.00
	10 Kg N/fed.	2184	1726	32.52	29.96
	20 Kg N/fed.	2412	1886	33.97	30.76
	Microbein	2027	1623	30.39	28.82
	10 Kg N/fed.+ Microbein	2223	1764	32.99	30.73
	20 Kg N/fed.+ Microbein	2449	1929	34.45	31.77
(3 : 1):					
	Without fertilization	2125	1670	30.96	27.95
	10 Kg N/fed.	2360	1870	32.83	30.50
	20 Kg N/fed.	2559	2003	34.89	31.80
	Microbein	2178	1748	30.99	29.57
	10 Kg N/fed.+ Microbein	2436	1932	33.21	30.95
	20 Kg N/fed.+ Microbein	2618	2055	35.28	32.41
(4 : 1):					
	Without fertilization	2300	1808	30.96	28.55
	10 Kg N/fed.	2558	2015	33.23	31.01
	20 Kg N/fed.	2727	2129	35.33	32.55
	Microbein	2377	1886	31.19	29.56
	10 Kg N/fed.+ Microbein	2626	2078	33.42	31.47
	20 Kg N/fed.+ Microbein	2796	2194	35.53	33.10
New L.S.D. $_{0.05}$		36.59	30.16	0.46	0.71

Control: Without catchment area.

4.2.11. Tillering index (%):

Data presented in Table (26) revealed the effect of strip size of water harvesting system and fertilization on tillering index % at harvest time of barley grown during 2011/2012 and 2012/2013 growing seasons.

Tillering index % reached its maximum by increasing catchment area up (4: 1) ratio. Increasing the catchment area up to the largest catchment area (4: 1) caused an increase in the tillering index. During the two seasons respectively, maximum mean values of tillering index (84.36 and 80.38 %) were obtained by (4: 1) ratio. On the other side, minimum values (79.88 and 76.13 %) during the two seasons respectively, were recorded by without leaving catchment area. In this respect, **Hassan *et al.*, (1998)** and **Attia, (2005)** demonstrated that, increasing the ratio between contributed area and cultivated area caused an increase in tillering index %.

Tillering index increased progressively with increasing the ratio between catchment area and cultivated area. Increasing the seeding zone moisture which increase the germination and population stand subsequently the ear bearing tillers/m^2 results in significant increased grain yield.

Mineral nitrogen and biofertilization had a significant effect on tillering index %, whereas the maximum mean values of tillering index (82.86 and 79.01 %) were obtained when plants received 20 kg N/fed. with biofertilization during the first and second seasons respectively, while minimum values (81.10 and 77.16 %) for both seasons respectively, were recorded by without mineral nitrogen and biofertilization treatment. Similar results were pointed by **Attia, (2005)**. The increase in tillering index may be due to the increase in vegetative growth of plant vigorous and N supply of photosynthetic formation of production tiller and spike **(Dubey and Sharma 1996)**.

The interaction effect between strip size of water harvesting system and (mineral nitrogen and biofertilization) on tillering index % was significant as shown in Table (27) during the two successive seasons. For first season, the highest value of tillering index (85.13 %) were recorded by using the interaction treatment ((4:1) with 20 kg N/fed. + biofertilization). For second season, the highest value of tillering index (81.51 %) were obtained by using the interaction treatment ((4:1) with 10 kg N/fed. + biofertilization). The lowest mean values (78.68 and 74.48 %) during the first and second seasons respectively, were recorded by the interaction treatment (without leaving catchment area in without mineral nitrogen and biofertilization). In this respect, **Garabet *et al.*, (1998**) demonstrated that, available soil water is principal factor that limits the yield potential and its response to mineral nitrogen.

4.2.12. Water use efficiency % (WUE) "kg/m^3"**:**

Data in Table (26) showed the effects of strip size of water harvesting system and (mineral nitrogen and biofertilization) on water use efficiency (kg/m^3) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Increasing catchment area from without catchment area up to largest catchment area (four times of cultivated area) caused an increase in water use efficiency with (57.4 and 59.1 %) during the two seasons respectively, compared with control treatment (without

Table (26): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on tillering index (%) and water use efficiency (%) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	Tillering index (%)		Water use efficiency (W.U.E.) (%) (kg/m^3)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	79.88	76.13	109.97	104.34
1 : 1	81.13	77.38	131.01	124.27
2 : 1	82.25	78.35	145.57	138.26
3 : 1	83.36	79.40	159.42	151.97
4 : 1	84.36	80.38	173.08	165.96
New L.S.D. $_{0.05}$	0.002	0.45	1.11	3.13
Fertilization (B):				
Without fertilization	81.10	77.16	119.21	110.52
10 Kg N/fed.	82.18	78.11	141.02	135.10
20 Kg N/fed.	82.64	78.55	162.27	151.25
Microbein	82.02	78.23	124.84	123.39
10 Kg N/fed.+ Microbein	82.37	78.90	147.04	141.76
20 Kg N/fed.+ Microbein	82.86	79.01	168.49	159.76
New L.S.D. $_{0.05}$	0.003	0.52	0.83	1.78
n:				
Interaction:				
AXB	0.006	1.10	1.85	3.98

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (27): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on tillering index (%) and water use efficiency (%) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		Tillering index (%)		Water use efficiency (W.U.E.) (%) (kg/m^3)	
		11/12	12/13	11/12	12/13
Control:					
	Without fertilization	78.68	74.48	88.27	81.60
	10 Kg N/fed.	79.91	75.68	105.59	102.09
	20 Kg N/fed.	80.27	76.04	123.22	114.65
	Microbein	79.95	76.01	98.88	95.46
	10 Kg N/fed.+ Microbein	80.05	76.64	112.64	107.94
	20 Kg N/fed.+ Microbein	80.42	77.92	131.24	124.31
(1 : 1):					
	Without fertilization	80.09	76.34	110.04	100.20
	10 Kg N/fed.	81.14	77.34	127.59	121.41
	20 Kg N/fed.	81.55	77.72	147.34	137.14
	Microbein	80.90	77.40	114.57	114.47
	10 Kg N/fed.+ Microbein	81.33	76.72	133.33	127.30
	20 Kg N/fed.+ Microbein	81.74	78.77	153.19	145.08
(2 : 1):					
	Without fertilization	81.19	77.22	120.98	111.53
	10 Kg N/fed.	82.18	78.16	143.59	136.48
	20 Kg N/fed.	82.64	78.60	165.58	153.16
	Microbein	82.24	78.47	124.48	123.45
	10 Kg N/fed.+ Microbein	82.38	79.17	148.29	143.09
	20 Kg N/fed.+ Microbein	82.89	78.49	170.52	161.82
(3 : 1):					
	Without fertilization	82.28	78.25	132.84	123.00
	10 Kg N/fed.	83.33	79.26	156.55	150.56
	20 Kg N/fed.	83.88	79.78	180.49	168.16
	Microbein	82.98	79.17	136.39	136.40
	10 Kg N/fed.+ Microbein	83.56	80.45	163.54	157.87
	20 Kg N/fed.+ Microbein	84.12	79.47	186.68	175.84
(4 : 1):					
	Without fertilization	83.25	79.48	143.88	136.24
	10 Kg N/fed.	84.33	80.13	171.78	164.94
	20 Kg N/fed.	84.87	80.64	194.73	183.11
	Microbein	84.04	80.11	149.89	147.15
	10 Kg N/fed.+ Microbein	84.55	81.51	177.38	172.60
	20 Kg N/fed.+ Microbein	85.13	80.40	200.81	191.74
New L.S.D. $_{0.05}$		0.006	1.10	1.85	3.98

Control: Without catchment area.

leaving catchment area). Increasing percentage differed with increasing catchment area from treatment to another i.e. without leaving catchment area, 1: 1, 2: 1, 3: 1 and 4: 1. The percentage increased progressively with increasing the ratio between catchment and cultivated area, whereas the comparison between without catchment area treatment and the other treatments was 19.1, 32.4, 44.9 and 57.4 %, respectively during the first season, while it was 19.1, 32.6, 45.6 and 59.1 %, respectively, during the second one.

The increase in water use efficiency may be due to increase in water supply by increasing the ratio between catchment and cultivated area. In this respect, **Zhang *et al.*, (1998)** reported that, water use efficiency was increased by 29 % for grain yield under rainfed conditions and 57 % under irrigated conditions. Similar findings were detected by **Attia, (2005)**. On the other side, opposite results were obtained by **Xiao** and **Dong, (2002)** whom reported that, no differences in WUE were obtained between 120: 60 cm ridge and furrow (120 cm wide ridge and 60 cm wide furrow) ratio system and 60: 60 cm ridge and furrow (60 cm wide ridge and 60 cm wide furrow) ratio system.

Mineral nitrogen and biofertilization had a significant effect on water use efficiency (kg/m^3) as shown in Table (26). The highest mean values of water use efficiency (WUE) were obtained by applying 20 kg N/fed. with biofertilization**,** the percentage increase was (41.3 and 44.6 %) during the first and second season respectively, increasing percentage differed with increasing mineral nitrogen rate with biofertilization from treatment to another i.e. control, 10 kg N/fed., 20 kg N / fed., biofertilization, 10 kg N / fed. with biofertilization and 20 kg N/fed. with biofertilization. The percentage increased progressively with increasing the mineral nitrogen rates with biofertilization inoculation, whereas the comparison between without fertilizer treatment and the other fertilizer treatments were 18.3, 36.1, 4.7, 23.3 and 41.3 %, respectively for the first season, while it was 22.2, 36.9, 11.6, 28.3 and 44.5 %, respectively, during the second one. The increase in water use efficiency with increasing N level may be due to the higher grain yield and the favorably affected plant height. Similar results were obtained by **Misra and Sen (1981)** pointed out that, the higher WUE with 120 kg N/ha. indicated proportionately much more photosynthetic areas of plants than water loss resulting in higher water use efficiency.

Concerning the interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization), results showed that, this interaction was significant for water use efficiency (kg/m^3) during the two seasons as shown in Table (27). Maximum mean values (200.81 and 191.74 kg/m^3) were recorded by using the interaction treatment ((144 m^2) with 20 kg N/fed. + biofertilization) during the first and second seasons, respectively. On the other hand, minimum values (88.27 and 81.60 kg/m^3) for the two seasons respectively, were obtained by the interaction treatment (without leaving catchment area in without mineral nitrogen and biofertilization).

4.3. Chemical Compositions:

4.3.1. Phosphorus percentage (P) %:

Data in Table (28) revealed that, the phosphorus percentage % in barley grains was significantly affected due to strip size of water harvesting system differences during 2011/2012 and 2012/2013 growing seasons. It was noticed that, the largest strip size of water harvesting system treatment (4: 1) ratio optioned the highest mean values of phosphorus percentage (1.20 and 1.14 %) during the first and second seasons, respectively.

Table (28): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on percentage of phosphorus and potassium at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	Phosphorus (%)		Potassium (%)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	1.15	1.11	0.697	0.695
1 : 1	1.16	1.11	0.698	0.698
2 : 1	1.18	1.12	0.701	0.699
3 : 1	1.19	1.13	0.703	0.701
4 : 1	1.20	1.14	0.704	0.703
New L.S.D. $_{0.05}$	0.013	0.012	N.S	N.S
Fertilization (B):				
Without fertilization	1.16	1.11	0.697	0.694
10 Kg N/fed.	1.14	1.09	0.700	0.698
20 Kg N/fed.	1.14	1.08	0.701	0.702
Microbein	1.23	1.16	0.702	0.703
10 Kg N/fed.+ Microbein	1.20	1.14	0.703	0.703
20 Kg N/fed.+ Microbein	1.19	1.13	0.702	0.702
New L.S.D. $_{0.05}$	0.004	0.005	N.S	N.S
Interaction:				
AXB	0.0096	0.0104	N.S	N.S

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

Table (29): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on percentage of phosphorus at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		Phosphorus (%)	
		11/12	12/13
Control:			
	Without fertilization	1.13	1.10
	10 Kg N/fed.	1.12	1.06
	20 Kg N/fed.	1.11	1.06
	Microbein	1.21	1.15
	10 Kg N/fed.+ Microbein	1.18	1.13
	20 Kg N/fed.+ Microbein	1.17	1.13
(1 : 1):			
	Without fertilization	1.14	1.10
	10 Kg N/fed.	1.12	1.07
	20 Kg N/fed.	1.13	1.07
	Microbein	1.21	1.15
	10 Kg N/fed.+ Microbein	1.19	1.13
	20 Kg N/fed.+ Microbein	1.18	1.12
(2 : 1):			
	Without fertilization	1.16	1.11
	10 Kg N/fed.	1.15	1.10
	20 Kg N/fed.	1.14	1.09
	Microbein	1.23	1.16
	10 Kg N/fed.+ Microbein	1.20	1.15
	20 Kg N/fed.+ Microbein	1.20	1.14
(3 : 1):			
	Without fertilization	1.17	1.12
	10 Kg N/fed.	1.15	1.10
	20 Kg N/fed.	1.15	1.09
	Microbein	1.23	1.16
	10 Kg N/fed.+ Microbein	1.20	1.14
	20 Kg N/fed.+ Microbein	1.21	1.14
(4 : 1):			
	Without fertilization	1.19	1.13
	10 Kg N/fed.	1.16	1.11
	20 Kg N/fed.	1.16	1.10
	Microbein	1.25	1.17
	10 Kg N/fed.+ Microbein	1.22	1.16
	20 Kg N/fed.+ Microbein	1.21	1.15
New L.S.D. $_{0.05}$		0.0096	0.0104

Control: Without catchment area.

On the other hand, minimum mean values (1.15 and 1.11 %) were achieved by without leaving catchment area treatment during the two seasons, respectively.

Mineral nitrogen and biofertilization had a significant effect on phosphorus percentage % in barley grains during both 2011/2012 and 2012/2013 growing seasons. It was noticed that, the high values of phosphorus (1.23 and 1.16 %) for the two growing seasons respectively, as shown in Table (28) was recorded by using biofertilization (Microbein) treatment without mineral nitrogen. The superiority value of grains inoculation may be due to the important role of microbe, which posses the ability to change insoluble phosphate in soil into soluble form by secreting organic acid, which lower the p^H of soil and some hidroxy acid may chelate with calcium and iron resulting in effective solubilization and utilization of phosphate. Also, the bacteria increased the endogenous phytohormones, which play an important role in formation a big active root system-increasing the nutrient uptake and translocation as well as accumulation within plant to storage part i.e. grains. Similar findings were found by **Barsoum, (1994)** as well as **Kumawat and Jat, (2005)**.

Concerning the interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization), data showed significant effects on phosphorus percentage due to this interaction for both seasons (Table 29). During the two seasons respectively, maximum phosphorus percentage (1.25 and 1.17 %) were detected by using the interaction treatment ((4: 1) ratio + biofertilization without mineral nitrogen). Minimum phosphorus percentage (1.11 %) during the first season were obtained by the interaction treatment (without catchment area in 20 kg N/fed without biofertilization). While for the second season, minimum value (1.06 %) were detected by the interaction treatment (without catchment area + 10 or 20 kg N/fed without biofertilization).

4.3.2. Potassium percentage (K) %:

Data presented in Table (28) showed that, potassium percentage was not affected by the strip size of water harvesting system and (mineral nitrogen and biofertilization) under this study for both seasons.

Decreasing of grains K-content may be due to the competition (Antagonism) between K and other elements (i.e. Na) on the soil exchange complex as well as the compression on exchange sites of roots account for plant K decrease.

Potassium percentage had not significantly affected due to the interaction between the two studied factors for both successive seasons.

4.3.3. Crude protein percentage %:

From data presented in Table (30). It can be pointed out that, crude protein percentage % in barley grains had slightly significant affected by the strip size of water harvesting system during 2011/2012 and 2012/2013 experimental seasons, due to increase in the moisture stress.

The crude protein % reached its maximum by decreasing catchment area. The highest mean values of crude protein percentage (12.03 and 12.57 %) during the first and second seasons respectively, were obtained by without leaving catchment area, while the

Table (30): Effect of catchment area ratio and (mineral nitrogen and biofertilization) on percentage of crude protein and protein yield (kg/fed.) at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments	Crude protein (%)		Protein yield (kg/fed.)	
	11/12	12/13	11/12	12/13
H : C (A):				
Control	12.03	12.57	65.52	49.76
1 : 1	12.00	12.53	77.87	59.04
2 : 1	11.98	12.51	86.39	65.58
3 : 1	11.97	12.48	94.48	71.90
4 : 1	11.95	12.46	102.47	78.42
New L.S.D. $_{0.05}$	0.012	0.009	0.65	1.45
Fertilization (B):				
Without fertilization	11.76	12.34	69.35	51.62
10 Kg N/fed.	11.97	12.49	83.47	63.90
20 Kg N/fed.	12.06	12.59	96.76	72.07
Microbein	11.95	12.45	73.79	58.18
10 Kg N/fed.+ Microbein	12.03	12.56	87.51	67.42
20 Kg N/fed.+ Microbein	12.14	12.64	101.20	76.45
New L.S.D. $_{0.05}$	0.011	0.010	0.49	0.84
Interaction:				
AXB	0.025	0.024	1.10	1.89

Control: Without catchment area.
H: Harvesting (Catchment) area.
C: Cultivated area.

lowest mean values (11.95 and 12.46 %) were recorded by (4: 1) ratio for both seasons, respectively. The percentage increased progressively with decreasing the ratio between catchment and cultivated area. In this respect, **Cheema *et al.*, (1973)** reported that, enhancing protein concentration in grains due to soil moisture stress. Also, **Nakhtore and Kewat, (1989)** showed that, the increase in irrigation frequencies showed decreasing trend in protein content. These results agree with those of **Attia, (2005)**.

As for mineral nitrogen and biofertilization, data in Table (30) revealed that, there was a significant effect for crude protein % in barley grains due to mineral nitrogen and biofertilization inoculation during the two growing seasons. The highest mean values of crude protein % (12.14 and 12.64 %) were detected when plants received 20 kg N/fed. with biofertilization during the first and second seasons respectively. On the other side, for two seasons respectively, the lowest mean values (11.76 and 12.34 %) were recorded by control treatment (without mineral nitrogen and biofertilization). The increase in crude protein percentage may be due to increasing in mineral nitrogen with biofertilization, because these factors affects on crude protein percentage. In this respect, **Barsoum, (1994)** as well as **Kumawat and Jat, (2005)** and **Mikhailouskaya and Bogdevitch, (2009)** found the same trend.

Grains protein content was significantly affected by mineral nitrogen application and biofertilization. Such increase in protein is referred to the role of mineral nitrogen in protein synthesis. These results were in harmony with those obtained by **Gomma, (1992)** who, reported that, the high mineral nitrogen levels improved protein content in barley grains.

Concerning the interaction effect between strip size of water harvesting system and (mineral nitrogen and biofertilization) on crude protein percentage, results in Table (31) revealed that, this interaction was significant for both seasons, whereas the highest mean values (12.19 and 12.70 %) for both seasons respectively, were achieved by using the interaction treatment (without leaving catchment area in 20 kg N/fed. with biofertilization). While, the interaction treatment ((4: 1) in without mineral nitrogen and biofertilization) gave the lowest mean values of crude protein percentage (11.73 and 12.29 %) during the first and second seasons, respectively. The increase in mineral nitrogen under drought conditions due to increasing in crude protein percentage. From above mentioned results, it could be noticed that, crude protein percentage in grains increased with increasing mineral nitrogen rates with biofertilizer inoculation and drought conditions and decreased with increasing catchment area ratio (water supply).

4.3.4. Protein yield (kg/fed.):

Protein yield of barley had significantly affected by the strip size of water harvesting system during 2011/2012 and 2012/2013 successive seasons as shown in Table (30).

For the first and second seasons respectively, the protein yield reached its maximum by increasing catchment area up to four times of cultivated area. Increasing the catchment area from without leaving catchment area up to the largest catchment area (4: 1) ratio caused an increase in protein yield (kg/fed.). The increase percent was differed with

Table (31): The interaction between catchment area ratio and (mineral nitrogen and biofertilization) on percentage of crude protein and protein yield at harvest time of barley grown during 2011/2012 and 2012/2013 seasons.

Treatments		Protein (%)		Protein yield (kg/fed.)	
		11/12	12/13	11/12	12/13
Control:					
	Without fertilization	11.80	12.40	51.54	38.32
	10 Kg N/fed.	12.01	12.56	62.74	48.57
	20 Kg N/fed.	12.10	12.65	73.77	54.94
	Microbein	11.99	12.52	58.65	45.26
	10 Kg N/fed.+ Microbein	12.08	12.63	67.31	51.63
	20 Kg N/fed.+ Microbein	12.19	12.70	79.14	59.82
(1 : 1):					
	Without fertilization	11.78	12.36	64.15	46.91
	10 Kg N/fed.	11.97	12.51	75.59	57.52
	20 Kg N/fed.	12.07	12.61	88.02	65.49
	Microbein	11.96	12.47	67.80	54.07
	10 Kg N/fed.+ Microbein	12.05	12.58	79.49	60.68
	20 Kg N/fed.+ Microbein	12.16	12.66	92.19	69.58
(2 : 1):					
	Without fertilization	11.76	12.33	70.36	52.10
	10 Kg N/fed.	11.96	12.49	84.98	64.58
	20 Kg N/fed.	12.07	12.60	98.87	73.10
	Microbein	11.94	12.44	73.53	58.19
	10 Kg N/fed.+ Microbein	12.02	12.56	88.22	68.06
	20 Kg N/fed.+ Microbein	12.14	12.63	102.39	77.44
(3 : 1):					
	Without fertilization	11.74	12.30	77.19	57.34
	10 Kg N/fed.	11.95	12.46	92.58	71.09
	20 Kg N/fed.	12.03	12.55	107.43	79.93
	Microbein	11.93	12.42	80.48	64.16
	10 Kg N/fed.+ Microbein	12.01	12.53	97.20	74.93
	20 Kg N/fed.+ Microbein	12.12	12.61	111.98	83.97
(4 : 1):					
	Without fertilization	11.73	12.29	83.50	63.42
	10 Kg N/fed.	11.94	12.45	101.47	77.77
	20 Kg N/fed.	12.01	12.53	115.73	86.90
	Microbein	11.93	12.42	88.49	69.22
	10 Kg N/fed.+ Microbein	12.00	12.51	105.32	81.81
	20 Kg N/fed.+ Microbein	12.11	12.59	120.31	91.43
New L.S.D. $_{0.05}$		0.025	0.024	1.10	1.89

Control: Without catchment area.

increasing catchment area from treatment to another i.e. without leaving catchment area, 1: 1, 2: 1, 3: 1 and 4: 1.

The percentage rate increased progressively with increasing the ratio between catchment area to cultivated area, whereas the comparison between without catchment area treatment and the other treatments were 18.8, 31.9, 44.2 and 56.4 %, respectively, for the first season, while it were 18.6, 31.8, 44.5 and 57.6 %, respectively, for the second one.

Mineral nitrogen and biofertilization inoculation had a significant effect on protein yield kg/fed. during the two seasons as shown in Table (30). The highest mean values of protein yield kg/fed. were obtained by the high dose of mineral nitrogen with biofertilization (20 kg N/fed. with biofertilization) than the other treatments of mineral nitrogen with biofertilization during the first and second season, the percentage increase was (45.9 and 48.1 %) during the two seasons respectively, increasing percentage was differed with increasing mineral nitrogen rates with biofertilization from treatment to another i.e. control, 10 kg N/fed., 20 kg N/fed., biofertilization, 10 kg N/fed. with biofertilization and 20 kg N/fed. with biofertilization. The percentage increase rates increased with increasing mineral nitrogen rates with biofertilization, whereas the comparison between without mineral nitrogen and biofertilization treatment and the other fertilizer treatments were 20.4, 39.5, 6.4, 26.2 and 45.9 %, respectively, for the first season, while for the second season, they were 23.8, 39.6, 12.7, 30.6 and 48.1 %, respectively. The increase in protein yield kg/fed. may be due to increasing in grain yield by mineral and bio-fertilization.

Protein yield of barley during 2011/2012 and 2012/2013 growing season experiments were significantly affected by the interaction between strip size of water harvesting system and (mineral nitrogen and biofertilization) as shown in Table (31). The highest values (120.31 and 91.43 kg/fed.) during two seasons respectively, were obtained by the interaction treatment ((4: 1) ratio with 20 kg N/fed. + biofertilization). On the other hand, for both seasons, lowest values (51.54 and 38.32 kg/fed.) were obtained by without catchment area in without fertilization.

The increase in protein yield kg/fed. may be due to increasing in the sink capacity and grain yield kg/fed. In this respect, **Attia, (2005)** found the similar results.

Generally, the increasing in parley yield and its attributes by mineral nitrogen and biofertilization (Microbein inoculation) might be due to:
1-*Azospirrillum brasilens* which improve growth of plants and produce high growth parameters, nutrient content, protein content **(Sawarker and Goydani, 1996)**.
2-The counts of *Azospirrillum spp*. increased with increasing the growth period to reach their maximum values during the grain formation stage decreased **(Zaghloul *et al*., 1996).**
3-The grains inoculation with *Azospirrillum brasilens* increased the growth, leaf area and its duration, photosynthesis, transpiration stomatal conductance and grain yield compared with uninoculation **(Panwar *et al*., 1990)**.
4-Biofertilization which is low coast was beneficent with balanced fertilization system, save fertilizers, give additional increase in barley yield and protect the age ecosystem from pollution. **(El-Akabwy *et al*., 2001)** and **(Berhanu *et al*., 2013)**.

Discussion between first season and second season.

From the above mentioned results, it was being noticed the following:

All growth characters, yield, yield components and water use efficiency for the first season expressed higher values than those obtained during the second season. This might be due to:

1. The high quantity and regular distribution of precipitations during winter season, also it was early during the first season that caused early cultivation and plant adaptation as well i.e. growth stage, adaptation of barley plants to meteorological factors which suitable to physiological process and increasing plant life period (Table 3).
2. Up to 60 % of precipitation was concentrated in Jan month (54.8 mm) as shown in Table (3) of the second season whereas, it was useless for vegetation.
3. The difference between two seasons for grain yield, yield components and water use efficiency may have been caused by different by environmental conditions between two seasons, i.e. quantity and distribution of rainfall over seasons which was different during the two seasons (Table 3).
4. The efficiency of runoff farming system was affected by the annual rainfall amount and rainfall distribution.
5. In rainfed agriculture, crop production is permanently dependent on the amount and distribution of rainfall. Seasonal rainfall is the most important factor effecting yields in the rainfed areas of West Asia and North Africa, up to 82 percent of the variation in grain yield was found to be determined by seasonal rainfall **(Christiansen, 1982)**. Also, **(Hadjichristodoulou, 1982)** found that, the percentage of variation in grain yield explained by annual precipitation varied with variety and species (5-13% in barley and 31-79% in wheat). The distribution of precipitating was the major factor effecting grain yield, although it varied with variety and explained 72-92 % of the variation in barley and from 75-98 % in wheat.

4.4. Economical Evaluation:

4.4.1. Impact of strip water harvesting system of farm income and economic efficiency:

To assess the impact of strip water harvesting system on farm income and efficiency of resource use, methods of total partial financial techniques are employed. The employed measures and indicators include: net returns per feddan (LE/fed.), the ratio of gross returns to costs (investment ratio) "LE/LE", and LE return (LE/m^3), comparison of the three measures for the four treatments with those in the control fields (traditional rainfall system) in made to show the impact of the strip water harvesting system on income and economic efficiency. Input-output data were collected for the control failed as well as the four treatments. Output data include the quantity and values of both main produce (grain yield) and by product (straw). Cost data include costs of farm input, labor and farm machinery. According the enterprise budget has been constructed and the three efficiency measures were calculated for the control and treatments as well.

Comparing the costs and returns for the control and the four treatments during the two seasons as shown in Table (32) reveals that:

1- The highest net return per feddan was obtained from treatment 4: 1 for the two growing seasons, the averages net return per feddan for without leaving catchment area and four treatments were 1430, 1732, 1959, 2169 and 2385 pound/fed. respectively. Moreover, the highest rate of increase in net return per feddan was witnessed in case of treatment 4: 1

when compared with that of control treatment (without leaving catchment area). For the average net return per feddan in four treatments had increased at 21.1, 37.0, 51.7 and 66.8% respectively.

2- The highest return per pound spent on barley cultivation (investment ratio) was also witnessed in treatment 4: 1, followed by 3: 1, 2: 1, 1: 1 and without leaving catchment area. As shown in Table (32) followed every pound spent yields an average of 3.34, 3.74, 4.00, 4.23 and 4.44 pound/pound in the without leaving catchment area and the four treatments, respectively.

3- The highest LE return was obtained from treatment 4: 1 for the two successive seasons, the averages of LE return are about 3.25, 3.87, 4.30 4.72 and 5.14 pound/m^3 for without leaving catchment area and four treatments i.e. 1:1, 2:1, 3:1 and 4:1 ratio, respectively. Moreover, the highest mean value of LE return was witnessed in case of treatment 4:1 when compared with control treatment (without leaving catchment area). For the average LE return in four treatments, it had increased at 19.1, 32.3, 45.2 and 58.2%, respectively.

4.4.2. Impact of mineral and bio-fertilization of farm income and economic efficiency:

The impact of mineral nitrogen and biofertilization had been assessed during the analysis of enterprise budgets. Three indicators have been used for evaluation: net return per feddan, the ratio of gross returns to costs (investment ratio) and LE return.

Comparison of estimates of the three measures for mineral nitrogen and biofertilization show that, the use of mineral nitrogen and biofertilization had a significant impact on farm income, as shown in Table (32).

Using the high level of mineral nitrogen with biofertilization is found to enjoy a good profit margin. For the average two seasons, net return per feddan, the ratio of gross returns to costs (investment ratio) and LE return increased from mineral nitrogen and biofertilization treatment to another, the maximum averages were 1622, 1903, 2129, 1746, 1984 and 2226 pound/fed. for net return per feddan and 3.82, 3.94, 3.95, 3.96, 4.00 and 4.03 LE/LE for investment ratio and 3.49, 4.19, 4.76, 3.77, 4.38 and 4.98 LE/m^3 for LE return for without fertilization and five treatments i.e. 10 kg N/fed., 20 kg N/fed., biofertilization, 10 kg N/fed. with biofertilization and 20 kg N/fed. with biofertilization, respectively.

4.4.3. Impact of the interaction between strip water harvesting system and (mineral and bio-fertilization) of farm income and economic efficiency:

With regard the interaction between the studied factors on economic indicators for both seasons as average, data pointed out in Table (33) showed that, the maximum averages values (2710 LE/feddan and 5.95 LE/m^3) of net return per feddan and LE return respectively, were achieved by using the interaction treatment ((4:1) ratio and 20 kg N/fed. with biofertilization), while the maximum average values for investment ratio (4.54 LE/LE) was recorded by using the same ratio of strip size of water harvesting system (4:1) but, in 10 kg N/fed. with biofertilization inoculation.

Table (32): Net return per feddan, investment ratio and LE return of barley under different water harvesting treatments and conditions of fertilizer use during 2011/2012 and 2012/2013 seasons at East Matrouh under rainfed conditions

able (33): Net return per feddan, investment ratio and LE return of barley under the interaction between different water harvesting treatments and conditions of fertilizer use during 2011/2012 and 2012/2013 seasons at East Matrouh under rainfed conditions

Conclusions:

Three economic implications (net return, investment ratio and LE return) could be concluded from the estimates of efficiency indicators related to the use of water harvesting techniques and (mineral and bio-fertilization) in barley production.

1. Improvement of barley production during using of water harvesting techniques and (mineral and bio-fertilizer) showed attractive return to investment and attractive return to use the cube meter of rain water irrigation.
2. The economic impact of water harvesting methods varies significantly, and therefore, cost benefit analysis should be carried out to determine the best ones to be used.

Generally, adding the strip size of strip water harvesting system (catchment): cultivated area "4: 1" (four times of cultivated area) and applying 20 kg N/fed. with inoculating barley grains by microbein as a biofertilization sores gave the highest grain yield for both seasons and enhanced the most of growth characters, yield components, water use efficiency and some chemical compositions of Giza 126 barley cultivar under rainfed conditions.