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Effectiveness of Azolla Extract In Reducing Use of Mineral Fertilizers (NPK) and Increasing Productivity of Wheat under New Reclaimed Soils

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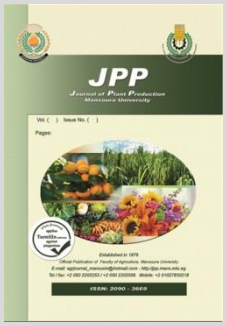

ABSTRACT

A field experiment was carried out in Al-Mijar Al-Kabeer District, 25 km South of Misan Governorate, Iraq, during 2016/17 and 2017/18 seasons to study effect of spraying with Azolla extract at 0, 20, 40 and 60% and NPK-fertilizers levels (60, 80 and 100% of the recommended doses "RD") on Egyptian wheat Sids 1cultivar productivity under new reclaimed soils. The experiment was applied according to split-plot design with three replicates.The results showed that increasing concentration of the Azolla extract resulted in an increase in most studied characters in both seasons. The increasing rate in grain yield was 57.37 and 51.71 % and in biological yield was 37.66 and 21.57 % for foliar spraying with Azolla extract at 60 % compared with control treatment in the first and second seasons, respectively. Most studied characters gradually increased due to increasing NPK-fertilizers levels from 60 to 80 and 100% of RD and without significant differences between 80 and 100% in both seasons. As for the interaction between spraying with Azolla extract levels and NPK-fertilizers levels, it was significant on spike length in 1st season only, number of spikes/m2, weight of 1000 grains and biological yield in both seasons. It can be stated that foliar spraying Egyptian bread wheat Sids 1cultivar with Azolla extract at 60 % alongside mineral fertilizing with 152.0 kg N + 42.8 kg P2O5 + 45.6 K2O ha-1 (80% of RD) to preserve high productivity simultaneously reduce production costs and environmental pollution under the environmental conditions of Misan, Iraq.

Keywords: Wheat, Azolla extract, mineral NPK levels, biological and grain yields

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop of *Poaceae* family. Its importance lies in its economic and strategic role in achieving food security. Wheat grains occupy the first place in the consumer food list because they provide the adult person more than 25% of protein and 50% of energy, as well as containing amino acids, minerals and vitamins (Saudi, 2013).

One of the most modern ways to develop crops and increase their growth is to provide their nutrients needs using some naturally occurring organic compounds, including the Azolla extract, which is called the green gold mine. The Azolla moss from the vital nutrients of agricultural crops, in order to provide a natural source of plant nitrogen and growing concern about preservation on the environment and the need for renewable and sustainable resources. Azolla can be of great importance to the future of organic agriculture as well as its environmental relevance and accessibility to many farmers in the world, especially those who cannot afford chemical fertilizers (Yadav *et al*, 2014). Azolla extract can be used to enhance the economic situation by increasing crop production with low costs and reducing environmental contaminants resulting from the use of chemical fertilizers (Kollah *et al*., 2016). Sulandjari and Yunindanova (2018) showed that application of Azolla at 200 g^{-2} could be improve plant growth, yield and properties of rice.

The active role for the nitrogen (N) is due to his contribution to improving the growth; in addition, to raise the efficiency of the total vegetable especially flag leave. Their role in the manufacture of amino acids, which transferred to the grain and contribute to the increase in production, potassium is not less important than nitrogen in its roles within the plant, as contributing too many important processes in the plant. The phosphorus (P) component plays an important role in most plant processes. It enters into the composition of energy compounds and helps stimulate growth and development of roots, cell division, maturity and seed formation (Havlin *et al.*, 2015). Potassium (K) is participate in photosynthesis, translocation of photosynthates, protein synthesis and enzyme activation in plants (Marschner, 1995). Nitrogen, phosphorus and potassium are the main nutrients needed by the plant in relatively large quantities as they contribute to increasing the grain yield and improve its quality. This increase comes from the important role of these elements and their contribution to many processes that occur within the plant, which increase the quantity and quality (Ali *et al.*, 2014). Khan *et al*. (2014) showed that application of 180 kg N/ha in combination with 90 kg K_2O/ha enhanced 1000-grain weight, grains weight/spike, grain yield and biological yield. Seadh and El-Metwally (2015) reported that fertilizing wheat plants with 80.0 kg N + 22.5 kg P_2O_5 + 24.0 K_2O/fed recorded the

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highest values of yields and its attributes. Seadh *et al*. (2017) showed that mineral fertilizing wheat plants with 80 kg N + 45.0 kg P_2O_5 + 48.0 K_2O/fed gave the highest values of growth characters followed by fertilizing 64.0 kg N + 36.0 kg P_2O_5 + 38.4 K_2O/fed.

Thus, aim of this study to assess the effect of spraying with the Azolla extract to reduce the use of mineral NPK fertilizers and increasing productivity of Egyptian bread wheat Sids 1 cultivar, which cultivated for the first time in Iraq under the conditions of newly reclaimed soils.

MATERIALS AND METHODS

Two field experiments were proceeded at Al-Mijar Al-Kabeer District, Misan, Iraq, during the winter seasons of 2016/2017 and 2017/2018, to evaluate the role of Azolla extracts in limiting usage of mineral NPK fertilizers and increasing Egyptian bread wheat Sids 1 cultivar productivity grown under newly reclaimed soil.

The experiments were carried out in a split-plot design with three replicates. Each experiment integrated twelve treatments comprising, four levels of spraying with Azolla extract, three mineral NPK fertilizers levels.

The main-plots were assigned to three foliar spraying with Azolla extract levels (20, 40 and 60 %), in addition control treatment (spraying with tap water). Azolla extract was extracted from fresh plant parts of Azolla depending on the extraction method according to Wilson *et al.* (1997) with slight modification. Firstly, washing the fresh plant part with tap water, followed by distilled water, then put in plastic bags with sterilized distilled water at a rate of 1 : 1 (weight/volume) and kept in the freezer for at least 12 hours at -20°C. The plant material is then withdrawn from the refrigerator and allowed to melt at room temperature. Freeze and dissolve plant cells, then plant cell fluids in the corner of the bags outside the tissue. The mixture was mixed for 5 minutes, filtered through double layers of cheesecloth, centrifuged at 12,000 rpm for 30 minutes and sterilized using a 0.22 µm pore membrane filter. The resulting solution was kept in the refrigerator at 5°C until use. The crude extract was considered 100% concentration and serial dilutions (0, 20, 40 and 60%) were performed using distilled water. The spraying was conducted by hand sprayer at 475 liters/ha until saturation point 3 times after 30, 45 and 60 days from sowing.

The sub-plots were allocated to three mineral NPK fertilizers levels as follows; 60 % of the recommended doses "RD" (114.0 kg N + 32.1 kg P_2O_5 + 34.2 K_2O/ha), 80 % of RD (152.0 kg N + 42.8 kg P_2O_5 + 45.6 K_2O/ha) and 100 % of RD (190.0 kg N + 53.5 kg P_2O_5 + 57.0 K_2O/ha).

P-fertilizer in the form of calcium superphosphate (15.5 % P_2O_5) at the above mentioned rates was useful during soil preparation. N-fertilizer in the type of ammonium nitrate (33.5 % N) at the aforementioned rates was applied in two equal doses prior the 1st and the 2nd irrigations. K-fertilizer in the form of potassium sulphate (48 % K_2O) at previously mentioned rates was applied in one dose before the 1st irrigation.

The soil of the experimental plots is clay loam with pH of 7.6, E.C. 7.2 dS m^{-1}, available nitrogen 10 mg kg^{-1} soil, available phosphorus 5.5 mg kg^{-1} soil and available potassium 145 mg kg^{-1} soil.

The experimental field was divided into experimental plots, dimension for each one was 3 × 3.5 m, occupying an area of 10.5 m^2.

Wheat seeds were sown at the rate of 190 kg/ha during the last week of November by using hand drilling method in both seasons. The common agricultural practices for growing wheat according to the recommendations of Ministry of Agriculture were followed, except the factors under study.

Studied characters:

At harvesting, one square meter was randomly selected from each sub-plot to estimate spike length (cm), number of spikes per m^2, number of spikelets $spike^{-1}$,number of grains $spike^{-1}$, weight of grains $spike^{-1}$ (g), weight of 1000 grains (g), grain and biological yields ($t ha^{-1}$).

The collected data were compiled and subjected to analysis of variance for the split-plot design as published by Gomez and Gomez (1984) using GenStat statistical computer package. LSD method was used to test the differences among treatment means (5% level of probability) as described by Al-Rawi and Khalaf (2000).

RESULTS AND DISCUSSION

1. Spike length (cm):

The obtained results show that foliar spraying with Azolla extract levels insignificantly affected length of the spike in both seasons (Table 1).

Fertilization at the top level of NPK (100 % of the RD) resulted in an increase in length of the spike, which was given a higher means (8.51 and 8.93 cm) for both seasons, respectively (Table 1). Whereas, the level 60 % of the RD of NPK gave the lowest average length of the spike (7.09 and 7.07 cm) for both seasons, respectively. These results may be due to the role of nitrogen phosphorus potassium elements in increasing the transmission of photosynthesis results from source to downstream in the plant, which led to an increase in spike length. These results are consistent with that reached by Zeboon (2016) who reported to NPK fertilization increase the length of spike.

The effect of the interaction between NPK levels and spraying by Azolla extracts significantly affected length of the spike in the first season only (Table 1). The highest average of length of the spike (8.80 cm) resulted from foliar spraying with Azolla extract at 40 % and application 100 % of the RD of NPK, while the lowest average of length of the spike (6.30 cm) resulted from foliar spraying with water (control treatment) and application 60 % of the RD of NPK.

2. Number of spikes per m^2:

The results in Table 2 charley show that spraying by Azolla extract led to a significant increase in the number of spikes per m^2 in both seasons, which recorded the highest averages 199.10 and 205.3 spike m^{-2} at the highest concentration (60%), while the control treatment gave the lowest number of spikes per m2 (176.0 and 190.8) for the two seasons in the sequence. The increases in the number of spikes per m^2 due to increasing concentrations of Azolla in the spray solution may be due to improved efficiency of root the absorption of water and

nutrients, which led to increased efficiency of photosynthesis and the transfer of output to the spikes. This result was consistent with what he referred to Yadav *et al*. (2014), Kollah *et al*. (2016) and Sulandjari and Yunindanova (2018).

The results in Table 2 indicate that there is a significant effect of NPK fertilization levels in increasing the number of spikes per m^2 in both seasons. The highest level of NPK levels (100 % of the RD) gave the highest mean of number of spikes per m^2 (199.3 and 205.1), which did not significantly differed from the second level (80 % of the RD), which gave the average of 188.3 and 196.7 spike m^2. While, the level of 60 % of the RD gave the lowest average of this character (177.9 and 188.7 spike m^2) for two seasons in the sequence. These results are agreed with Seadh and El-Metwally (2015) and Seadh *et al*. (2017), who found an increase in the number of spikes per m^2 when increasing fertilizing with NPK on wheat.

The effect of the interaction between NPK fertilization and spraying with Azolla showed significant differences in the number of spikes per m^2 in both seasons. It was observed that the combination of the highest concentration of Azolla at 60% and the second concentration of NPK fertilization (80 % of the RD) produced the highest number of spikes per m^2 (204.3 and 210.3 spike m^{-2}) in both seasons, respectively. While, the combination of control treatment (without Azolla) and 60 % of the recommended NPK doses gave the lowest mean of number of spikes per m^2 (157.1 and 179.6 (Spike m^{-2}) for the two seasons on the relay (Table 2).

Table 1. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on spike length (cm) during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla extract	**NPK-levels**			**Means of Azolla extract**
	60%	**80%**	**100%**	
Control	6.30	7.43	8.30	7.34
20%	7.16	7.60	8.32	7.69
40%	7.33	7.70	8.80	7.94
60%	7.56	8.13	8.63	8.11
Mean of NPK-levels	7.09	7.72	8.51	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	NS	0.74	0.84	
Second season (2017/2018)				
Azolla extract	NPK-levels			Means of Azolla extract
	60%	80%	100%	
Control	6.36	7.43	8.66	7.48
20%	7.23	7.60	8.85	7.89
40%	7.33	7.70	9.20	8.08
60%	7.36	8.00	9.03	8.13
Mean of NPK-levels	7.07	7.68	8.93	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	NS	0.80	NS	

Table 2.Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on number of spikes per m^2 during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla extract	**NPK-levels**			**Means of Azolla extract**
	60%	**80%**	**100%**	
Control	157.1	172.3	198.7	176.0
20%	178.7	182.3	195.7	185.6
40%	184.7	194.3	201.0	193.3
60%	191.2	204.3	201.9	199.1
Mean of NPK-levels	177.9	188.3	199.3	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	5.9	11.8	12.9	
Second season (2017/2018)				
Azolla extract	NPK-levels			Means of Azolla extract
	60%	80%	100%	
Control	179.6	188.3	204.6	190.8
20%	185.6	188.3	201.6	191.8
40%	191.6	200.0	206.6	199.4
60%	198.0	210.3	207.6	205.3
Mean of NPK-levels	188.7	196.7	205.2	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	3.9	10.2	10.4	

3. Number of spikelets spike^{-1}:

The effect of spraying with Azolla extract at various levels had a significant effect on number of spikelets spike^{-1} during the seasons (Table 3). It could be observed that the highest concentration Azolla extract (60%) having the highest mean of number of spikelets spike^{-1} (20.14 and 19.89 spikelets spike^{-1}) for the first and second seasons on the relay, which was not significantly different from Azolla extract levels at 40% and 20%. While, control treatment (without application of Azolla extract) was given the lowest average for this character (18.23 and 18.33 spikelets spike^{-1}) of the two seasons on the sequence.

Fertilization levels of NPK under study *i.e.* 60%, 80% and 100% of the RD were significantly affected number of spikelets spike^{-1} in the two growing seasons as shown in Table 3. The level of NPK fertilization (100% of the RD) recorded the highest number of spikelets spike^{-1} (20.37 and 20.16) of the two seasons on the sequence. The second level of NPK fertilization (80% of the RD) did not significantly differed from the highest level (100 % of the RD), which recorded 19.58 and 19.58 spikelets spike^{-1} for the two seasons, respectively. While, the level of 60% recorded the lowest values of number of spikelets spike^{-1} (18.41 and 18.34) in the first and second seasons, respectively. This result agreed with Seadh and El-Metwally (2015) and Seadh *et al*. (2017).

The interaction between spraying with Azolla extract and NPK fertilization levels showed insignificant effect on number of spikelets spike^{-1} in both seasons.

4. Number of grains spike^{-1}:

Results presented in Table 4 show that the effect of foliar application of Azolla extract levels, fertilization with NPK levels and their interaction on number of grains spike^{-1} was insignificant in both seasons (Table 4).

Table 3. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on number of spikelets spike^{-1} during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla	**NPK-levels**			**Means of**
extract	**60%**	**80%**	**100%**	**Azolla extract**
Control	16.77	18.27	19.67	18.23
20%	18.23	19.77	19.93	19.31
40%	19.30	20.03	20.00	19.78
60%	19.33	19.23	21.87	20.14
Mean of NPK-levels	18.41	19.32	20.37	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	1.00	0.93	NS	
Second season (2017/2018)				
Azolla	NPK-levels			Means of
extract	60%	80%	100%	Azolla extract
Control	16.71	18.67	19.63	18.33
20%	18.00	20.00	20.33	19.44
40%	19.33	20.33	19.67	19.78
60%	19.33	19.33	21.00	19.89
Mean of NPK-levels	18.34	19.58	20.16	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.99	0.88	NS	

Table 4. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on number of grains spike^{-1} during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla	**NPK-levels**			**Means of**
extract	**60%**	**80%**	**100%**	**Azolla extract**
Control	43.33	47.33	47.00	45.89
20%	46.33	44.67	49.33	46.78
40%	48.33	49.00	49.33	48.89
60%	44.67	50.67	53.00	49.45
Mean of NPK-levels	45.67	47.92	49.67	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	NS	NS	NS	
Second season (2017/2018)				
Azolla	NPK-levels			Means of
extract	60%	80%	100%	Azolla extract
Control	45.33	47.67	47.67	46.89
20%	47.67	47.67	50.67	48.67
40%	49.67	49.67	51.00	50.11
60%	46.33	51.00	53.67	
Mean of NPK-levels	47.25	49.00	50.75	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	NS	NS	NS	

5. Weight of grains spike^{-1} (g):

The obtained results show that the effect of spraying with Azolla extract levels significantly affected weight of grains spike^{-1} in the two growing seasons (Table 5). The highest concentration of Azolla extract (60 %) gave the highest average of weight of grains spike^{-1} (2.53 and 2.70 g) in the first and second seasons, respectively. While, the control treatment was given less average for a weight of grains in spike of 1.80 and 1.91 g for both seasons on the relay. The superiority of spraying with the Azolla extract may be due to the presence of nitrogen in its formulation, which is included in many plant processes including photosynthesis and then increasing grain weight in the spike (Kiguli, 2000).

NPK fertilization levels under study *i.e.* 60, 80 and 100 % of the RD were significantly affected weight of grains spike^{-1} in the first and second growing seasons (Table 5). In the two grown seasons under in newly reclaimed soil, application of 100% of the recommended NPK doses gave the heaviest grains (2.42 and 2.55 g) in the first and second seasons, respectively. While, application of 80% of the recommended NPK doses ranked secondly after 100% of the RD without significant differences between them in both season. Whereas, using 60 % of the recommended NPK doses gave the lowest mean of this characters (1.89 and 2.03 g) in the first and second seasons, respectively. This result was agreed with what was indicated by Khan *et al*. (2014), Seadh and El-Metwally (2015) and Seadh *et al.* (2017).

The interaction between spraying with Azolla extract and NPK fertilization levels showed insignificant effect on weight of grains spike^{-1} in both seasons.

Table 5. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on weight of grains spike^{-1} (g) during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla extract	**NPK-levels**			**Means of Azolla extract**
	60%	**80%**	**100%**	
Control	1.64	1.83	1.93	1.80
20%	1.71	2.09	2.41	2.07
40%	1.87	2.48	2.60	2.32
60%	2.36	2.46	2.76	2.53
Mean of NPK-levels	1.89	2.21	2.42	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.16	0.23	NS	
Second season (2017/2018)				
Azolla	NPK-levels			Means of
extract	60%	80%	100%	Azolla extract
Control	1.75	1.90	2.08	1.91
20%	1.82	2.16	2.47	2.15
40%	2.11	2.56	2.67	2.44
60%	2.46	2.68	2.98	2.70
Mean of NPK-levels	2.03	2.32	2.55	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.18	0.24	NS	

6. Weight of 1000 grains (g):

Spraying wheat plants with Azolla extract levels significantly affected the weight of 1000 grains in both seasons (Table 6). Spraying wheat plants with Azolla extract at concentration of 60% significantly increased weight of 1000 grains than other studied concentrations, which gave the highest averages of this characters (50.24 and 52.31 g) in the first and second seasons, respectively. While, control treatment (spraying with water) gave the lowest averages weight of 1000 grains (40.46 and 41.65 g) for the first and second seasons, respectively. These results are in agreed with those reported by Bindhu (2013), who indicated that the weight of the grain was increased when Azolla was added to the green pea yield.

The results in Table 6 show that raising NPK fertilizers levels from 60, 80 to 100% of the RD caused significant increases in weight of 1000 grains in both seasons. Highest values of weight of 1000 grains (48.49 and 49.45 g) were recorded due to application of 100% of the recommended NPK doses with no significant difference from level of 80 % of the recommended NPK doses, which recorded 46.40 and 47.57 g in the first and the second seasons, respectively. On opposition to, the lowest values of weight of 1000 grains were produced from the least level of NPK fertilizers *i.e.* 60% of the RD (41.71 and 44.98 g in the first and the second seasons, respectively. These results probably due to the provision of essential nutrients and their role in the activation of vital processes and some enzymes and regulation to work of hormones, which contributed to the increased transmission of photosynthesis products to the spike and thus increased the weight of the grains. These results are consistent with the findings by Khan *et al*. (2014), Seadh and El-Metwally (2015) and Seadh *et al*. (2017).

The interaction between levels of Azolla extract and NPK fertilization had a significant effect on the weight of 1000 grains for both seasons (Table 6). The combination treatment of 60% Azolla extract and 100 % NPK levels was given the highest averages of this characters (52.40 and 53.87 g) for two seasons frequently, which did not significantly different than the combination treatment of 40% Azolla extract and 100 % NPK levels, 60% Azolla extract and 80 % NPK levels and 40% Azolla extract and 80 % NPK levels in both seasons. While, the combination treatment of without Azolla extract (control treatment) and 60 % NPK levels gave the lowest averages for weight of 1000 grains, which were 38.73 and 41.00 g for the first and second seasons, respectively.

Table 6. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on weight of 1000 grains (g) during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla	**NPK-levels**			**Means of**
extract	**60%**	**80%**	**100%**	**Azolla extract**
Control	38.73	40.69	41.96	40.46
20%	39.71	43.70	48.27	43.90
40%	40.20	51.10	51.31	47.54
60%	48.19	50.11	52.40	50.24
Mean of NPK-levels	41.71	46.40	48.49	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	2.03	2.37	3.26	
Second season (2017/2018)				
Azolla	NPK-levels			Means of
extract	60%	80%	100%	Azolla extract
Control	41.00	41.19	42.76	41.65
20%	43.65	44.50	49.07	45.64
40%	45.47	51.60	52.11	49.73
60%	49.79	53.28	53.87	52.31
Mean of NPK-levels	44.98	47.57	49.45	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	1.74	2.05	2.69	

7. Grain yield (t ha^{-1}):

The obtained results of this study show that there was a significant effect in grain yield/ha with increasing concentrations of Azolla extracts in the spray solution for both seasons (Table 7). The higher concentration of Azolla extract (60 %) gave a significantly higher increases in grain yield than the rest concentrations, which recorded 4.80 and 5.31 t ha^{-1} with an increase of 57.37 and 51.71 % % than control treatment (spraying wheat plants with tap water without Azolla extract), which gave the lowest values of grain yield (3.05 and 3.50 t ha^{-1}) for the first and second of seasons, respectively. These result was consistent with what found Yadav *et al.* (2014), Kollah *et al.* (2016) and Sulandjari and Yunindanova (2018).

Data presented in Table 7 show that the increases in grain yield when NPK fertilization levels increased in both seasons. With level 100% of the recommended NPK doses giving the highest average for grain yield, which reached 4.61 and 5.02 t ha^{-1}, with the increases of 43.16 and 37.91 % than the level 60% of the recommended NPK doses, which recorded the lowest average of grain yield (3.22 and 3.64 t ha^{-1}) for two seasons, respectively. However. 80% of the recommended NPK doses ranked secondly after 100% of the recommended NPK doses without significant differences between them in both season. The reason for the increase in grain yield may be due to the higher fertilization level of NPK in the yield components likes the number of spikes per m^2 (Table 2) and the weight of 1000 grains (Table 6). This results agreed with what obtained by Meena *et al.* (2013), Khan *et al*. (2014), Seadh and El-Metwally (2015) and Seadh *et al*. (2017).

The interaction between spraying with Azolla extract and NPK fertilization levels showed insignificant effect on grain yield in both seasons.

Table 7. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on grain yield (t ha^{-1}) during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla	**NPK-levels**			**Means of**
extract	**60%**	**80%**	**100%**	**Azolla extract**
Control	2.46	3.05	3.64	3.05
20%	2.89	3.66	4.50	3.68
40%	3.27	4.58	4.99	4.28
60%	4.28	4.79	5.33	4.80
Mean of NPK-levels	3.22	4.02	4.61	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.16	0.23	NS	
Second season (2017/2018)				
Azolla	NPK-levels			Means of
extract	60%	80%	100%	Azolla extract
Control	2.98	3.44	4.09	3.50
20%	3.19	3.92	4.77	3.96
40%	3.82	4.89	5.28	4.66
60%	4.60	5.39	5.95	5.31
Mean of NPK-levels	3.64	4.41	5.02	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.33	0.62	NS	

8. Biological yield (t ha^{-1}):

The effect of spraying wheat plants with the extract of Azolla gave a significant effect on biological yield in both seasons (Table 8). The highest levels of Azolla extract at 60% gave the highest average of this characters, which were 6.36 and 8.85 t ha^{-1} in the first and second seasons, respectively. While, the control treatment gave the lowest average of the biological yield, that were 4.62 and 7.34 t ha^{-1} in the first and second seasons, respectively. The reason for excellence of concentration 60% of Azolla extract in the biological yield may be attributed to the increase in grain yield (Table 7), which contributed to the increase in biological yield (Bindhu, 2013).

The results of the two seasons in Table 8 indicate a significant effect in biological yield increasing levels of NPK fertilizers. The highest level of NPK fertilization (100 % of the RD) recorded the highest values of biological yield (6.11 and 8.42 t ha^{-1}) in the first and second seasons, respectively. However, application of 80% of the recommended NPK doses ranked secondly after application of 100% of the RD without significant differences between them in both season, which recorded 5.63 and 7.96 t ha^{-1} in the first and second seasons, respectively. On the other hand, the level of 60 % of the recommended NPK doses gave a lowest averages of the biological yield, which were 4.96 and 6.88 t ha^{-1} for two seasons, respectively. The increase in 100 % and 80% % of the recommended NPK doses were due to its superiority in grain yield (Table 7), which resulted in a significant increase in the biological yield. These results were consistent with the findings of Al-Hilfy and Flayyah (2017), who indicated an increase in the biological yield when increasing levels of NPK fertilization.

There was also a significant effect of the interaction between spraying with Azolla extracts and NPK fertilization levels and on biological yield during both seasons (Table 8). The highest level of Azolla extract (60 %) and NPK fertilization (100 % of the RD) gave the highest averages of biological yield (7.12 and 10.79 t ha^{-1}) in the first and second seasons, respectively. While, the combination treatment of spraying wheat plants with tap water without Azolla extract and application of 60 % of the recommended NPK doses gave the lowest averages of biological yield (4.30 and 6.44 t ha^{-1}) for the two seasons in the sequence.

Table 8. Effect of foliar spraying with Azolla extract levels and mineral NPK fertilizers levels as well as their interaction on biological yield (t ha^{-1}) during 2016/2017 and 2017/2018 seasons.

First season (2016/2017)				
Azolla	**NPK-levels**			**Means of**
extract	**60%**	**80%**	**100%**	**Azolla extract**
Control	4.30	4.57	5.27	4.62
20%	4.96	5.53	5.67	5.38
40%	5.31	6.00	6.40	5.90
60%	5.55	6.41	7.12	6.36
Mean of NPK-levels	4.96	5.63	6.11	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.19	0.49	0.30	
Second season (2017/2018)				
Azolla	NPK-levels			Means of
extract	60%	80%	100%	Azolla extract
Control	6.44	7.64	7.60	7.23
20%	6.78	7.63	7.27	7.23
40%	6.89	8.21	8.00	7.70
60%	7.39	8.36	10.79	8.85
Mean of NPK-levels	6.88	7.96	8.42	
LSD (0.05)	Azolla	NPK	Azolla × NPK-levels	
	0.49	0.45	0.77	

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فعالية مستخلص الأزولا في الحد من استخدام الأسمدة المعدنية (NPK) وزيادة إنتاجية القمح تحت ظروف الأراضى الجديدة حديثة الإستصلاح

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نفذت تجربة حقلية في منطقة المجر الكبير (٢٥ كم جنوب محافظة ميسان، العراق) خلال المواسم الزراعية ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ لدراسة تأثير الرش الورقي بأربعة تراكيز من مستخلص الازولا (بدون ، ٢٠ ، ٤٠ و ٦٠٪) وثلاثة مستويات من الأسمدة المعدنية (NPK) وهي؛ ٦٠ ، ٨٠ و ١٠٠ ٪ من المعدلات السمادية الموصى بها لصنف القمح المصري سدس ١ تحت ظروف الأراضى حديثة الإستصلاح. طبقت التجربة وفقا لتصميم القطع المنشقة باستخدام تصميم القطاعات كاملة العشوائية فى ثلاث مكررات. أظهرت النتائج أن زيادة تركيز مستخلص الأزولا في محلول الرش أدى إلى زيادة معنوية في معظم الصفات تحت الدراسة في كلا الموسمين. حيث كان معدل الزيادة محصول الحبوب ٥٧.٣٧ و ٥١.٧١ ٪ وفي المحصول البيولوجي كان ٣٧.٦٦ و ٢١.٥٧ ٪ نتيجة للرش الورقي بمستخلص الأزولا بتركيز ٦٠ ٪ مقارنة بمعاملة المقارنة (رش بالماء) في الموسمين الأول والثاني ، على التوالي. من ناحية أخرى ازدادت معظم الصفات المدروسة تدريجيا نتيجة لزيادة مستويات الأسمدة المعدنية (NPK) من ٦٠ إلى ٨٠ و ١٠٠ ٪ من التوصيات السمادية من دون فروق كبيرة بين المستويين ٨٠ و ١٠٠ ٪ على التوالي في كلا الموسمين. بالنسبة للتفاعل بين الرش الورقي بمستخلص الأزولا مستويات الأسمدة المعدنية (NPK)، فقد كان له تأثيرا معنوياً على صفات طول السنبلة في الموسم الأول فقط ، عدد السنابل لكل متر مربع ، وزن ١٠٠٠ حبة والمحصول البيولوجي في كلا الموسمين. عموماً يوصى بالرش الورقي لصنف قمح الخبز المصري سدس ١ ثلاث مرات بعد ٣٠ و ٤٥ و ٦٠ يومًا من الزراعة بمستخلص الأزولا بتركيز ٦٠٪ مع التسميد المعدني بـ ٨٠ % من المعدلات الموصى بها (١٥٢.٠ كجم N + ٤٢.٨ كجم P_2O_5 + ٤٥.٦ كجم K_2O / هكتار) وذلك للحفاظ على إنتاجية وفي نفس الوقت خفض تكاليف الإنتاج الزراعى وتقليل التلوث البيئي تحت الظروف البيئية لميسان ، العراق.