Bulgarian Journal of Agricultural Science, 31 (No 4) 2025, 741–747

Effect of previous agriculture on growth, forage and grain yield of barley

Salim Abdullah Younis Al-Ghazal*, Waleed Khalid Shahatha Al-Juheishy and Moyassar Mohammed Aziz

University of Mosul, Field Crops Department, College of Agriculture and Forestry, Post code:41002, Mosul, Iraq
**Corresponding author:* salimalghazal@uomosul.edu.iq

Abstract

Al-Ghazal, S. A. Yo., AL-Juheiehy, W. K. Sh. & Aziz, M. M. (2025). Effect of previous agriculture on growth, forage and grain yield of barley. *Bulg. J. Agric. Sci., 31*(4), 741–747

The study was conducted in three consecutive agricultural seasons, (2020–2021), (2021–2022), and (2022–2023), in three locations in Nineveh Governorate: – First location was in east of Mosul / Bashiqa district / Tobzawa village, which is 25 km far away from the center of Mosul; Second location was in west of Mosul in Hamidat district / Althalja village, which is far 15 km from The center of Mosul city, and the third location was in the village of Alshuhada, which is located northwest of the city of Mosul, which is 35 km away from the center of Mosul city. All locations are considered within areas, that are semi-guaranteed rain regions. The experiment included nine treatment combinations that represented the combinations between three sites and three levels of previous agriculture. All experiments applied according to the split-plot system, were designed in a completely randomized block design with three replicates, where the sites being occupied by the main plots and the previous cultivation being the secondary plots. The important results are summarized as follows: The first cultivation system achieved the highest values for all growth traits, feed and grain yield, and protein percentage, while the lowest values for most of the traits studied were in the third cultivation system. The highest values were achieved for most of the studied traits in the first site (Tobzawa), and the lowest values were for most of the studied traits in the third site (Alshuhada).

Keywords: Semi-guarantee rainfall regions; barley; previous agriculture; feed; growth

Introduction

The barley crop *Hordeum spp.*, characterized by its tolerance to harsh conditions, its low nutritional requirements, and its sufficient uses compared to other winter grass fodder crops (Naeem et al., 2020). It exploited for grazing or as green and dry fodder, silage, and hay, in addition using its grains as concentrated fodder for livestock in the winter (Taherianfar et al., 2020). Regarding area under cultivation and production, barley is ranked second in Iraq behind wheat. Barley grows in all regions of Iraq, and the Nineveh Governorate ranks first in terms of area and production, as the cultivated area in the 2021 -2 022 agricultural season, is estimated at about (500 000 ha) (Nineveh Agriculture Directorate/ planning department). One of the most important reasons that makes the barley crop grown in extensive areas in dry areas, is because it tolerates drought more than all other fodder crops. It is always grown in dry and semi-arid areas, and its production from planting to harvest requires only an amount of rain ranging from (200 to 350 mm) distributed as good distribution during the growing season (Al-Idlabi et al., 2021). Tillage process is not only major factor responsible for agricultural soil degradation, but there are other factors (AL-Ghazal, 2021; Al-Obady et al., 2022), which found that following agricultural cycles, that are stressful to the soil, such as wheat – wheat or barley – barley, led to the deterioration of agricultural soil, an increase in weeds, diseases, and insects, as well as a decrease in soil fertility and a decrease in organic matter, organic carbon, and total nitrogen. Sieling et al. (2005) and Paustian et al. (2016), had also found through

studies that planting wheat successively in the same fields, led to reducing the yield by half compared to what planted after fallow, where the crops planted after fallow gave a yield equivalent to seasonal production agriculture, and most studies indicate that the crop should not be repeatedly grown on the same land, because each crop has its own nutritional requirements, as well as avoiding infection by diseases, insects and weeds (Malash, et al., 2008; Peltonen-Sainio, 2012; Altieri et al., 2015).

Because each site has unique environmental variables that set it apart from other places, location plays a significant role in barley crop yield. This is especially true if agriculture depends on rain, as it is the primary determinant in semi-arid areas for crop productivity. Given the lack of studies on previous cultivation systems of the subsequent crop, we decided to carry out this study in areas, where rain semi-guaranteed, because it most important areas for growing barley. We followed the same farmer‘s method of agriculture and did not use any crop that is not grown in these areas, whether leguminous or not The aim of current study is to select the best area for growing barley, and also to choose the best previous cultivation, i.e. is it better to grow barley after fallow or after barley or wheat?

Materials and Methods

The study was conducted in three consecutive seasons (2020–2021), (2021–2022), and (2022–2023), in three locations in Nineveh Governorate, as follows: The first location was east of Mosul/Bashiqa district/Tobzawa village, which is 25 km far away from the center of Mosul. The second location was west of Mosul in Hamidat district/Althalja village, which is far away 15 km from the center of the city of Mosul, and the third location was in the village of Alshuhada, which is located northwest of Mosul which is 35 km away from the center of the city of Mosul. The sites are located within areas that are semi-guaranteed rainfall. Table 1 shows the correspondences between (three locations) and (three levels of previous agriculture) in the experiment, which included 9 treatments‘ combinations. The split-plot system was used in the experiment, applying a completely randomized block design (RCBD) with three replicates. The main plots were occupied by the sites, while the secondary plots were occupied by the previous cultivation sites. The distance between one replicate and another was 1 m and between the experimental unit and another (0.5 m), planting process done in six lines with 6 m as length. The distance among lines was (15 cm). The local black barley is cultivated with a seed rate of 160 kg/ha. Planting took place in the three seasons at the first week of December. The studied traits as follows: Plant height [PH] (cm), Number of total tillers [NTT] (tillers. m^{-2}), Fresh weight yield [FWY] (kg. ha^{-1}), Dry weight yield [DWY] (kg. ha^{-1}). In addition, Yield and it’s components were: Spikes number per square meter [SN](Spikes. m^{-2}), Spike grains number [SGN](grains. $spike^{-1}$), Thousand grains weight [1000GW](g)., Straw yield [SY] (kg. ha^{-1}), protein percentage in dry fodder [Prot.] (in grains and straw). Results were obtained for only two seasons (2020–2021) and (2022–2023). There are no results obtained for (2021–2022) season, due to the lack of rainfall and its poor distribution. The amount of rainfall in the agricultural season of (2020–2021) in Tobzawa location was 175 mm, rainfall amounts on Althalja and Alshuhada locations were 220 mm, but in the (2022–2023) season, it was 140 in Tobzawa and in Althalja and Alshuhada locations were 267.5 mm. All locations were irrigated once every season for safe germination, also irrigated once during the stage of spikes expelling, to avoid failure in obtaining grain yield. The amount of water in each irrigation was 30 l. m^{-2} (Table 2).

Results and Discussion

Effect of three previous cultivation systems on growth characteristics and fodder yield of barley

Table 1. Physical and chemical characteristics of the soil at the experimental locations

Components	Tobzawa	Althalja	Alshuhada	Units
Sand (%)	225	77.0	75.0	$g.kg^{-1}$
Clay (%)	432	393	497	$g.kg^{-1}$
Silt (%)	343	530	427	$g.kg^{-1}$
Texture	Silty Clay	Silty Clay Loam	Silty Clay	
pH	7.1	7.5	7.1	
EC.	1.1	1.88	2.4	$ds.m^{-1}$
Availability of (N)	60	54.0	89.0	$g.kg^{-1}$
Availability of (P)	3.0	4.0	3.5	$mg.kg^{-1}$
Availability of (K)	12	382.0	256.7	$mg.kg^{-1}$
Organic matter	2.0	1.90	2.06	$g.kg^{-1}$

Table 2. The previous and subsequent cultivation in the three sites in the 2020–2021, and 2022–2023 seasons

Agricultural systems locations	Previous cultivation 2019–2020	Subsequent cultivation 2020–2021	Previous cultivation 2021–2022	Subsequent cultivation 2022–2023
System 1	No tillage	barley	barley	barley
System 2	wheat	barley	wheat	barley
System 3	barley	barley	No tillage	barley

The data presented in Tables 3, 4 and 5, shows that the three previous agricultural systems (fallow – barley, wheat – barley, and barley – barley), had a significant impact on all the traits that were studied, and in the 2020–2021, and 2022–2023 growing seasons, except for the spikes number per square meter, weight of thousand grains, and percentage of protein in grains. It was not significantly affected by the three agricultural systems in the first agricultural season 2020–2021, and the data in the same table shows that where, the first system (fallow – barley), outperformed the second and third systems in terms of plant height, and the highest plants reached (40.11 and 48.35 cm) in both seasons (first and second seasons, respectively), and it was less plant height in the third system (barley – barley) was (31.33 and 40.96 cm) in first and second seasons, respectively. The reason may be the fertility of soil (Table 1), as the fallow was devoid of any crops, meaning fertility was not depleted like the second and third systems, because their soils were cultivated with crops (wheat and barley), respectively.

The results in Table 3 shows the superiority of the first system with a significant difference over the second and third systems, in terms of the number of tillers.m^{-2}, as the number of tillers in the first system reached (263.67 and 272.33) tillers.m^{-2}, and the lowest number of tillers were in the third system, which reached (207.33 and 219.78) tillers.m^{-1} in both seasons , respectively. The higher number of tillers in the first system may be because of higher fertility that came from fallow in the first system. The data in same table shows that the yield of fresh and dry fodder in the first cropping system was higher than in the second and third systems and reached (1567.67, 1756.56; 524.44, and 640.22) kg. ha^{-1} in both seasons, respectively, while the lowest yield of fresh and dry fodder in the third cropping system was (1264.11, 1387.67, 366.22, and 414.11) kg.ha^{-1}, in both growing seasons, respectively. The superiority of the first agricultural system in the yield of fresh and dry fodder may be because of its superiority in the two characteristics of plant height and number of tillers.m^{-2}.

The results in Table 4 indicates the superiority of the first system in the traits of the number of spikes.m^{-2}, and the number of grains per spike, where reached in both seasons (226.56 and 219.22) spikes.m^{-2} and (15.56 and 15.11) grains.spike^{-1}. The weight of 1000 grains in both seasons were (29.89 and 36.1 g), respectively. The lowest average of the characteristics of the third system was (201.56, 166.56) spikes.m^{-2}, (14.67 and 14.11) grains.spike^{-1} in both seasons, while (34.33) g for weight of 1000 grains in second season. The superiority of the first system in these characteristics may be due to the significant traits of growth (plant height, number of tillers, fresh and dry fodder weight), which means an increase in the amount of photosynthesis, which reflected positively in an increase in the weight of grains. Table 4 shows the first system outperformed the total grains yield which reached to (1112.11, and 1078.56) kg.ha^{-1},while the lowest grains yield were in third system (885.44, and 885.22) kg.ha^{-1} in both seasons, respectively. The reason may be due to its superiority in yield components, i.e. spikes No. per m^2, number of grains per spike, and weight of thousand grains.

The results in Table 5 shows significant differences in straw yield and achieved the highest straw yields were reached to (2309, and 2029.56) kg.ha^{-1} in both seasons, respectively. The lowest straw yield in the third system was (2107.11, and 1890.67) kg. ha^{-1}, respectively. As for its superiority in straw yield, it may be because of the superiority of the first system in plant height and number of tillers. m^{-2}. The protein percentage in (grains, straw, and dry fodder) (Ta-

Table 3. Effect of previous cultivation on growth traits [PH, NTT, FDW] of barley in seasons (2020–2021) and (2022–2023)

Previous Cultivation	PH (cm)		NTT tillers.m^{-2}		FWY (kg.ha^{-1})		DWY (kg.ha^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
System 1	41.44^{a}	48.35^{a}	263.67^{a}	272.33^{a}	4567.67^{a}	4756.56^{a}	524.44^{a}	641.22^{a}
System 2	37.78^{a}	43.42^{b}	227.56^{b}	256.44^{b}	4346.11^{b}	4422.78^{b}	434.44^{b}	474.22^{b}
System 3	34.33^{b}	41.96^{c}	217.33^{c}	249.78^{c}	4264.44^{b}	4387.67^{b}	366.22^{c}	444.44^{b}

The averages that have the same letters mean there are no significant at 5%

Table 4. Effect of previous cultivation on the yield, and its components traits of fodder and grains of the barley crop in the 2020–2021, and 2022–2023 seasons

Previous Cultivation	SN Spikes.m^{-2}		GS Grains. Spikes^{-1}		1000GW (g)		GY (kg. ha^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2 nd season
System 1	226.56^{a}	249.22^{a}	45.56^{a}	45.44^{a}	29.89^{a}	36.44^{a}	4442.44^{a}	4178.56^{a}
System 2	245.78^{a}	492.44^{b}	45.44ab	44.67ab	31.44^{a}	35.22ab	968.67^{b}	4145.33^{b}
System 3	214.56^{a}	466.56^{c}	44.67^{b}	44.44^{b}	31.56^{a}	34.33^{b}	885.44^{c}	885.22^{c}

The averages that have the same letters mean there are no significant at 5%

ble 5), was higher in the first system was (11.07, 10.89%; 2.46, 2.75%, 9.38, and 10.23%), in both seasons, respectively, while the lowest percentages were in the third system, (10.85, 10.89%; 2.04, 2. 17%, and 8.76, 9.41%), respectively. The superiority in protein percentages may be because of highest soil content of nitrogen in the first system which reflected positively in an increase in the protein percentages, also it may be because of its superiority in plant height and tillers number when plant height and tillers increase, the leaves number increases, and increasing the leaves number causes an increase in protein because, as is known leaves contain three times more protein percentage than the stems.

Effect of locations on growth characteristics and yield of barley fodder and grains

The data presented in Table 6, indicate the superiority of the first location (Tobzawa) outperformed second and third locations (Althalja and Alshuhada) in the characteristics of PH, NTT, and yield of fresh and dry fodder, where the averages of these characteristics reached 39.67 and 45.63cm (for plant high), 270.0 and 268.33 tillers.m^{-2} (for tillers number per square meter), 1466.67 and 1786.78 kg. ha^{-1} (as fresh fodder), 465.67 and 600.0 kg. ha^{-1} (as dry fodder), and the lowest averages for these characteristics were at the third location were 33.44 and 42.99 cm, 211.0 and 220.33 cm, 1266.78 and 1346.44 kg. ha^{-1}, 194.89 and 166.89 kg. ha^{-1} in both seasons, respectively. The superiority of the first location in traits plant height and number of tillers.m^{-2}, may be because of its superiority in the amount of rain falling, besides the superiority of the soil of this location in nitrogen content (Table 1). As for its superiority in the yield of fresh and dry fodder, it may be because of the superiority of the plants of this location in plant height and the number of tillers. m^{-2}.

The averages that have the same letters mean there are no significant at 5%. The data in Table 7 shows that the first location was superior in traits: the number of spikes.m^{-2} in both seasons, respectively, which were 244.67 and 225.89 spikes.m^{-2}. The lowest number of spikes.m^{-2} in the third location were 194.89 and 166.89 spikes.m^{-2} in first and second seasons.

The first location in [SN] for both seasons may be because of the same reasons, that were mentioned when discussing in

Table 5. Effect of previous cultivation on the straw yield and protein percentages for straw and fodder of barley crop in the 2020–2021, and 2022–2023 seasons

Previous Cultivation	SY (kg.ha^{-1})		Prot. (%)		Straw protein percentage		Protein content in dry fodder	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
System 1	2319.11^{a}	2129.56^{a}	44.17^{a}	41.89^{a}	2.46^{a}	2.75^{a}	9.38^{a}	41.23^{a}
System 2	2417.78^{b}	4946.56^{ab}	44.14^{a}	41.49^{a}	2.23^{a}	2.57^{b}	8.97^{b}	9.71^{ab}
System 3	2417.44^{b}	4891.67^{b}	41.85^{a}	9.49^{b}	2.14^{b}	2.47^{c}	8.76^{b}	9.44^{b}

The averages that have the same letters mean there are no significant at 5%

Table 6. Effect of locations on growth traits (Plant height, Number of tillers, Fresh and Dry weight) of barley in seasons 2020–2021, and 2022–2023

Locations	PH (cm)		NTT tillers.m^{-2}		FWY (kg.ha^{-1})		DWY (kg.ha^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Tobzawa	39.67^{a}	45.63^{a}	271.11^{a}	286.33^{a}	4466.67^{a}	4786.78^{a}	465.67^{a}	611.11^{a}
Althalja	36.44ab	44.44ab	247.57^{b}	244.89^{ab}	4444.33^{ab}	4433.78^{b}	444.22^{a}	487.22^{ab}
Alshuhada	33.44^{b}	42.99^{b}	244.11^{b}	221.33^{b}	4266.78^{b}	4346.44^{b}	448.22^{a}	438.33^{b}

The averages that have the same letters mean there are no significant at 5%

Table 6. There were no significant differences in trait of the number of grains per spike in first season, while there were significant differences with the number of grains per spike among the three locations in the second season, where the highest number of grains per spike was achieved at the first location, was 15.44 grains.spike^{-1}, and the lowest number of [GS] was 13.78 grains.spike^{-1}. There were no significant differences among locations in [1000GW] in the both seasons. The achieving the highest grain yield at the first location was 1107.2 and 1083.78 kg. ha^{-1}, and the lowest [GY] at the third location were 895.67 and 907.67 kg.ha^{-1}, in both seasons, respectively. The superiority of the first location in grain yield may be because of the superiority of location's plants in the number of spikes. m^{-2}.

The averages that have the same letters mean there are no significant at 5%. The data in Table 8 shows superiority of the first location in straw yield were reached to 2344.22 and 2086.22 kg.ha^{-1} in first and second seasons respectively, while the lowest averages were at third location 1987.44 and 1775.33 kg.ha^{-1}, for both seasons, respectively. The reason of superiority in first location may be due to the superiority of location's plants in [PH] and [NTT]. The data in Table 8 indicate content of protein percentage in grains at the first location was higher than the third location, reaching 10.48% in the second season only. The first location superiority in content of protein percentage in grains, may be because of superiority in growth traits, the content of protein percentage of first location in straw and dry fodder were superior to the third location, where reaching to 2.31, 2.87%, 9.44, and 10.19% in both seasons, respectively. The lowest percentage of protein in straw and fodder at the third location were 2.03 and 2.00%, and 8.74, 9.19% in both seasons, respectively. The superiority of the first location in content of protein percentage in straw and fodder, may be because of its superiority in [PH] and [NTT], where increasing the plant height and number of tillers leads to an increase in the number of leaves per plant, and as it is known that the protein content of the leaves is three times what the stems contain.

Effect of the interaction between (Previous cultivation) and (Locations) on the growth characteristics and yield of fodder and grains of the barley crop for the 2020–2021, and 2022–2023 seasons

The data in Tables 9, 10, and 11 shows that the interaction between the three farming systems and locations was significant for all the traits studied in both seasons. Where the interaction of the first system with the first location recorded the highest averages for the characteristics of PH, NTT, and (fresh and dry fodder), each of them reached 47.76 and 48.89 cm (as plant height), 303.0 and 298.33 tiller.m^{-2}, and 1668, 2233.3 kg. ha^{-1} (as fresh fodder), 571.67 and 756.67 kg. ha^{-1} (as dry fodder), in both seasons, respectively. The interaction of the first system with the first planting location obtained the highest averages for NGS, and SY, also content of protein percentage straw and dry fodder, which were 16.3, 16 grains.spike^{1}, and 1223, 1166.67 kg. ha^{-1}, 2590 and 2178 kg .ha^{-1}, 2.6,3.24% and 9.72,10.39%, in both seasons, in the previous order. The lowest averages were achieved from the interaction of the third system with the third location for each characteristic of PH, NTT, and yield of fresh and dry fodder, which were 39.6, 26.6 cm, 185.67, 191.6 tiller.m^{-2}, 1107.3, 1278 kg. ha^{-1}, and 356.67, 336.33 kg. ha^{-1}, while the same interaction

Table 7. Effect of locations on the yield and it's components traits of fodder and grains of the barley crop in the 2020–2021, and 2022–2023 seasons

Locations	SN (Spikes.m^{-2})		GS grains.spikes^{-1}		1000GW (g)		GY (kg.ha^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
1st Location	244.67^{a}	225.89^{a}	45.67^{a}	45.44^{a}	31.67^{a}	36.44^{a}	4417.22^{a}	4183.78^{a}
2nd Location	214.33^{b}	485.44^{b}	45.11^{a}	44.67^{b}	31.44^{a}	34.56^{a}	963.33^{b}	987.67^{b}
3rd Location	494.89^{b}	466.89^{c}	44.67^{a}	43.78^{c}	31.44^{a}	34.67^{a}	895.67^{c}	917.67^{c}

The averages that have the same letters mean there are no significant at 5%

Table 8. Effect of locations on the straw yield and protein percentages for straw and fodder of barley crop in the 2020–2021, and 2022–2023 seasons

Locations	SW (kg.ha^{-1})		Prot. (%)		Protein in straw (%)		Protein content in dry fodder	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
1st Location	2344.22^{a}	2186.22^{a}	44.14^{a}	41.48^{a}	2.34ab	2.87^{a}	9.44^{a}	41.49^{a}
2nd Location	2492.22^{b}	2115.22^{a}	41.85^{a}	41.42ab	2.44^{a}	2.62^{b}	8.93^{b}	9.96ab
3rd Location	4987.44^{c}	4775.33^{b}	44.168^{a}	9.96^{b}	2.13^{b}	2.11^{c}	8.74^{b}	9.49^{b}

The averages that have the same letters mean there are no significant at 5%

gave the lowest values for the characteristics of NS, NGS, and the yield of grains and straw. The protein in straw were 177.3, 145.3, and 14.3, 13.3 grains.spike^{-1}, 786.00, 765.67. kg. ha^{-1}, 1985.3, 1728 kg. ha^{-1}, and 1.8, 1.91%, in both seasons, in the previous order.

Conclusions

The first agricultural system outperformed most of the studied traits, whether growth or yield traits, over the second and third systems in the two growing seasons. In addition,

Table 9. Effect of locations on the plant height, tillers No., Fresh and dry weight of barley crop in the 2020–2021, and 2022–2023 seasons

Locations	Previous Cultivation	PH (cm)		NTT tillers.m^{-2}		FWY (kg.ha^{-1})		DWY (kg.ha^{-1})	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
1st Location	System1	47.67^{a}	48.89^{a}	313.1^{a}	298.3^{a}	4668.1^{a}	2233.3^{a}	574.7^{a}	756.67^{a}
	System2	44.33ab	45.66ab	264.1^{b}	281.3ab	4364.3^{bc}	4567.1^{b}	448.3bcd	563.3bc
	System3	35.11cd	42.34bc	246.1bc	281.33^{ab}	4367.7^{bc}	4561.1^{b}	377.1cd	481.1cd
2nd Location	System1	39.67abc	47.76^{a}	256.3bc	269.33^{bc}	4556.1^{ab}	4616.7^{b}	516.1^{ab}	619.1^{b}
	System2	36.33bcd	43.62bc	242.1de	263.11^{bc}	4369.7^{bc}	4369.7^{c}	432.3bcd	451.1cde
	System3	32.33^{d}	41.94^{c}	484.3^{f}	493.33^{c}	4347.3bcd	4325.1^{c}	385.3bcd	412.67^{de}
3rd Location	System1	38.11abc	48.44^{a}	234.7cd	249.33^{cd}	4479.1^{ab}	4429.7^{bc}	495.7abc	555.11^{bc}
	System2	35.67cd	41.97^{c}	219.67^{de}	226.11^{d}	4244.1^{cd}	4334.7^{c}	422.7bcd	411.33^{de}
	System3	26.67^{e}	39.61^{c}	494.7ef	485.67^{e}	4417.3^{d}	4278.1^{c}	336.33^{d}	356.67^{e}

The averages that have the same letters mean there are no significant at 5%

Table 10. Effect of locations on SN, GNS, 1000GW, and GY of barley crop in the 2020–2021, and 2022–2023 seasons

Locations	Previous Cultivation	SN (Spikes.m^{-2})		GS grains.spikes^{-1}		1000GW (g)		GY (kg.ha^{-1})	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
1st Location	System1	238.33^{ab}	242.11^{a}	46.33^{a}	46.11^{a}	31.33^{a}	37.11^{a}	4223.3^{a}	4466.7^{a}
	System2	259.11^{a}	236.67^{ab}	45.67^{ab}	45.67ab	34.11^{a}	37.11^{a}	4419.1^{ab}	4195.3^{ab}
	System3	236.67^{ab}	499.11^{c}	45.11bc	44.67bcd	31.67^{a}	35.33ab	989.3^{bc}	989.33^{c}
2nd Location	System1	227.1abc	248.67^{b}	45.33abc	45.11abc	31.33^{a}	35.67ab	4431.3^{a}	4179.1^{b}
	System2	495.33^{bc}	484.33^{c}	45.11^{bc}	44.67bcd	31.11^{a}	34.33ab	878.67^{cd}	983.33^{c}
	System3	491.67^{bc}	455.33^{d}	44.67bc	44.33bcd	31.11^{a}	33.67^{b}	884.11^{cd}	911.67^{d}
3rd Location	System1	244.3abc	497.11^{c}	45.11^{bc}	44.33bcd	29.11^{a}	35.67ab	982.67^{bc}	991.11^{c}
	System2	493.11^{bc}	458.33^{d}	44.67bc	43.67cd	31.33^{a}	34.33ab	948.33^{cd}	967.33^{cd}
	System3	477.33^{c}	445.33^{d}	44.33^{c}	43.33^{d}	34.11^{a}	34.11^{b}	786.11^{d}	765.67^{e}

The averages that have the same letters mean there are no significant at 5%

Table 11. Effect of locations and previous cultivations on the straw yield and protein percentages for straw and fodder of barley crop in the 2020–2021, and 2022–2023 seasons

Locations	Previous Cultivation	SY (kg.ha^{-1})		Prot. (%)		Protein in straw (%)		Protein content in dry fodder	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
1st Location	System1	2591.1^{a}	2478.1^{a}	44.17ab	44.13^{a}	2.62^{a}	3.24^{a}	9.72^{a}	41.39^{a}
	System2	2227.3^{bc}	2187.3^{ab}	44.18ab	41.66^{a}	2.47ab	2.95^{b}	9.74^{a}	41.25^{a}
	System3	2245.3^{bc}	4993.3^{bc}	41.94ab	9.76ab	2.43ab	2.43^{c}	8.88bcd	9.94ab
2nd Location	System1	2339.7^{b}	2154.3^{ab}	41.97ab	44.13^{a}	2.64^{a}	2.91^{b}	9.72ab	41.45^{a}
	System2	2444.3^{cd}	2141.7^{bc}	41.93ab	41.57^{a}	2.44^{a}	2.78^{b}	8.84bcd	9.81ab
	System3	2422.7^{cd}	4951.7^{bc}	41.64^{b}	9.67ab	2.47ab	2.48cd	8.69cd	9.63ab
3rd Location	System1	4997.3^{d}	4856.3^{cd}	44.47^{a}	41.61^{a}	2.46ab	2.41^{d}	9.45bc	9.87ab
	System2	4979.7^{d}	4744.7^{d}	44.13ab	41.23ab	2.41ab	4.99^{d}	8.37^{d}	9.15ab
	System3	4985.3^{d}	4728.1^{d}	44.11ab	9.13^{b}	4.83^{b}	4.94^{d}	8.71cd	8.66^{b}

The averages that have the same letters mean there are no significant at 5%

the first location, (Tobzawa), excelled in all growth characteristics and became the second and third sites in the two growing seasons. Finally, the interaction between the first system and the first cultivation site resulted in the highest grain yield during the two growing seasons.

References

AL-Gazhal, S. A. (2021). Nitrogen fertilizer and effect of forage grass crops: article review. *Mesopotamia Journal of Agriculture, 49*(4). https://www.iasj.net/iasj/download/61d96e952c4e158b.

Al-Idlabi, Reem, Al-Shahadha, A., Al-Awda & Baladiya, R. (2021). Evaluating the performance of locally adopted barley varieties under conditions of rain-fed agriculture and supplementary irrigation. *Hama University Journal*, 4, 1 – 15.

Al-Obady, R. F. A., Ghazal, S. A. Y. & Al-Juheishy, W. K. S. (2022). Effect of some agricultural process on growth and yield of sorghum (*Sorghum bicolor* L.)(article review). *Mesopotamia Journal of Agriculture, 50*(4), 117-126. https://www.iasj.net/iasj/download/02b623faed87138b.

Altieri, M. A., Nicholls, C. I., Henao, A. & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development, 35*(3), 869 – 890. https://link.springer.com/article/10.1007/s13593-015-0285-2.

Malash, N. M., Flowers, T. J. & Ragab, R. (2008). Effect of irrigation methods, management, and salinity of irrigation water on tomato yield, soil moisture and salinity distribution. *Irrigation Science, 26,* 313 – 323. https://link.springer.com/article/10.1007/s00271-007-0095-7.

Naeem, M., Mehboob, N., Farooq, M., Farooq, S., Hussain, S., M. Ali, H. & Hussain, M. (2020). Impact of different barley-based cropping systems on soil physicochemical properties and barley growth under conventional and conservation tillage systems. *Agronomy, 11*(1), 8. https://www.mdpi.com/2073-4395/11/1/8.

Paustian, K., Lehmann, J., Ogle, S., Reay, D., Robertson, G. P. & Smith, P. (2016). Climate-smart soils. *Nature, 532*(7597), 49 – 57. https://www.nature.com/articles/nature17174.

Peltonen-Sainio, P. (2012). Crop production in a northern climate. Building resilience for adaptation to climate change in the agriculture sector, 23, 183. Available online at: http://www.fao.org/agriculture/crops/newsevents-bulletins/detail/en/item/134976/ (accessed December 28, 2020).

Sieling, K., Stahl, C., Winkelmann, C. & Christen, O. (2005). Growth and yield of winter wheat in the first 3 years of a monoculture under varying N fertilization in NW Germany. *European Journal of Agronomy, 22*(1), 71 – 84. https://www.sciencedirect.com/science/article/abs/pii/S1161030104000115.

Taherianfar, A., Hadidi Masouleh, E., Eskandari, A., Sayfzadeh, S. & Soufizadeh, S. (2020). Comparison of triple interaction of tillage, nitrogen fertilizer, and barley varieties on biochemical traits and chlorophyll content. *Arch Pharma Pract, 11*, 98 – 109.
https://archivepp.com/storage/models/article/XXa4gSSmBHtrh-1PjZE8Agwk94YUTw7SmWpffxUQzea1fwWx O8jWgVP-GHW9R7/comparison-of-triple-interaction-of-tillage-nitrogen-fertilizer-and-barley-varieties-onbiochemica.pdf.

Received: **April, 07, 2024**; *Approved*: **September, 16, 2024;** *Published:* **August, 2025**