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Dual purpose barley culture

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ABSTRACT

Dual-purpose cereals culturally provide the opportunity to graze a crop during the vegetative phase, and still harvest grain yield at the end of the growing season. It can also help to face climatic changes like frost or dry conditions risk. The aim of the study was to determine the benefits of a dual-purpose barley culture in relation to livestock feed, human nutrition, risk mitigation, and whether a malting variety can also be used for dual-purpose use. A field experiment was carried out in the farm of Nubaria Agricultural Research Station, El-Behera Governorate, Egypt, using five barley varieties during the two successive growing seasons of 2019/2020 - 2020/2021 for dual purpose utilization. No significant differences between the two seasons. The cutting treatment revealed significant or highly significant differences on all studied traits except number of tillers.m^{-2} and number of spikes.m^{-2}. Green forage weight was highly significantly affected. Concerning normal cultivation, the differences among the five barley cultivars were highly significant for all studied traits except number of spikes m^{-2}. Significant or highly significant differences were found among studied traits concerning cultivars and cutting treatment interaction. Normal cultivation conditions also exhibited that Giza 132 gave the highest grain yield followed by Giza133 and Giza 126. While Giza 2000 gave the heaviest green forage weight followed by Giza 133 and Giza 126 under dual purpose utilization. Moreover, under dual purpose utilization, Giza 126 and Giza 2000 were the best barley cultivars for both green forage and grain yield production. The existing improved dual barley variety conserve the purpose in specified environment as alternative for the green forage demand without sacrificing the grain yield in the rainfed, arid, and semi-arid regions of Egypt.

Keywords: Barley, Dual purpose, green fodder, Cut, Grain yield

INTRODUCTION

Barley (*Hordeum vulgare,* L.) is the best choice to be cultivated under risky conditions in Egypt, such as poor fertile soils and newly reclaimed areas suffering from water shortage and low water quality (El-Banna *et al*., 2017). Globally, there were 46.9 million hectares of barley cultivated in 2019, yielding approximately 141 million tons, according to FAOSTAT (2020) with a yearly output of 17.9 million tons, the Russian Federation leading the world's barley producers. Germany, France, Ukraine, Australia, and Canada are next, yielding 10.7, 10.3, 9.4, 8.9, and 8.7 million tons, respectively. Total barley cultivated areas in Egypt occupied about 84.9 thousand feddans with an average production of 91.35 thousand tons during the period 2004/2005 through 2018/2019. The most cultivable area was about 147.2 thousand feddans in 2005/2006, with a total output of 107.7 thousand tons, while the smallest area was approximately 53.6 thousand feddans in 2018/2019, with a production of approximately 73.68 thousand tons. According to the Egyptian Ministry of Agriculture and Land Reclamation's 2004/2019 A and B reports, this shows a consistent drop in cultivated land at a rate of roughly 6.4% over this time. In the growth season of 2020–2021, there were 53.3 thousand feddans of total barley planted, yielding 87.6 thousand tons with a productivity of 1.6 tons/fed (Egyptian Ministry of Agriculture and Land Reclamation 2020–2021, c). Despite its low water requirements compared to the other cereal crops, farmers are reluctant to grow barley due to marketing and lower market prices. On the other hand, Bedouins in the North-Coastal Areas don't have many choices; they grow barley year after year under rainfed conditions for food and feed. The recently suggested better cultivars are more resistant to barley diseases and pests and yield less than their indigenous types of barley (Bosily et al., 2018). The primary crop farmed in considerable quantities in the North Coastal region of Egypt and on recently reclaimed lands with saline soils and a lack of fresh water is barley. Due to its nutritious and healthful qualities, it has also been utilized as human food. It is mostly used for animal feeding. In the northern coastal regions of around 250–300 thousand feddans, cultivation is concentrated in rainfed areas (Shawky *et al*., 2022). Barley productivity under rainfed conditions reached 0.3 ton.fed^{-1} with the total production of 33.52 tons in the northwest coastal region (Egyptian Ministry of Agriculture and Land Reclamation). The rate of rainfall varies in that area, ranging from 80 mm west of Al-Arish to 280 mm at Rafah in the northeast, and from 130 to 150 mm in the northwestern coast (Yacout *et al*. 2018). The Nile Valley's barley area has gradually decreased, particularly in areas where soil and irrigation are attainable and where other critical crops like wheat can be grown (Bosily *et al*., 2018). About 150,000 tons from the total production usually go to animal feeding, also about 30,000 tons to the industry use and about 4000 tons is going to human use (Barley Research Department, ARC, unpublished dada). Therefore, the primary uses of barley are as animal feed (approximately 81%), malt (17%), and human nutrition (2%; Idehen et al., 2017; Kumar et al., 2020). Potential barley production losses were claimed to be decreased from 48 and 85% in North Sinai and Marsa Matrouh, respectively, to 12 and 71% by Ouda et al. (2016). Due of its multiple purposes and low environmental needs, farmers can produce barley (Verma *et al*., 2007). Animal husbandry plays a significant role, and there is a significant fodder supply and demand discrepancy. Barley has a benefit in that both the green crop and grains can be used as feed and fodder. So, through its green fodder and grains taken from the regenerated crop, barley may offer vital nourishment to livestock. However, in terms of types, sowing dates, seed rates, dosages, and timings for applying fertilizer and irrigation, dual-purpose barely cultures should follow different agronomic methods than forage cultures or cultures that increase grain output for humans. The ideal sowing window for dual purpose barley culture was identified by Singh et al. (2017) as mid-October to mid-November. The expansion of crops cultivation in Egypt has increased the depletion of irrigation and ground water during recent years. Many researchers today are trying to develop alternatives to high water consuming crops (Al-Doss and Moustafa, 2002). Thus, Nubaria Research Station represents arid, semiarid, rainfed areas and newly reclaimed calcareous soils in Egypt. It is deeply involved in the barley breeding program of the Barley Research Department. This prompted the present study's recommendation to assess five barley cultivars for dual-purpose culture, optimize agronomic practices for forage and grain yield, view dual-purpose barley net profitability, and evaluate the potential use of barley cultivars as dual-purpose crops for forage and grain production.

MATERIALS AND METHODS

The field Experiment was carried out at the experimental farm of Nubaria Agricultural Research Station, El-Behera Governorate, Egypt, during the two successive growing seasons of 2019/2020 and 2020/2021. The soil of the experimental site was sandy clay loam. Cutting and no cutting treatments were applied on the selected five six rowed barley cultivars. Plot size was 6 rows, 20 cm apart and 3.5 m length (4.2 m^2). The planting date was November st in the two successive growing seasons. The experimental design was split blot arrangement in Randomized Complete Block Design with three replications. The first factor was (C1: without cutting as control and the second factor was C2: cutting after 55 days from sowing) were occupied the main plots, and five barley cultivars (Giza 126, Giza 132, Giza 133, Giza 134, and Giza 2000) were randomly arranged in the sub plots, with the seeding rate of 50 Kg/fed. Phosphorus and potassium fertilizers were applied as recommended Kharub *et al*. (2013). Four Irrigations with three nitrogen fertilizer doses, at the rate of 45 Kg N/fed, were applied at twenty-five days after sowing, after cut treatment and after 20 days from cut, for better rejuvenation according to Kharub *et al*. (2013). 55 days after sowing, green fodder was collected. to estimate the fresh forage weight. Data were collected on plant height (cm), number of tiller m^{-2}, number of spike m^{-2}, peduncle length (cm) and grain yield (ardab.fed^{-1}). According to the procedures recommended by Steel and Torrie (1980), a combined analysis of variance for the two growth seasons was performed for all studied traits using SAS Program (SAS, 1988).

RESULTS

The results of the two consecutive growing seasons, combined analysis of variance in Table 1 showed significant or highly significant differences among cutting treatments for all studied traits except number of tillers and number of spikes m^{-2}.

Table 1. Analysis of variance over all seasons, treatments and cultivars.

s.o.v	d.f	Plant height (cm)	Number of tillers.m^{-2}	Number of spikes.m^{-2}	Green forage (ton.fed^{-1})	Grain yield (ardab.fed^{-1})	Peduncle length (cm)
Season	**1**	0.600 n.s	666.667 n.s	3681.667 n.s	0.726 n.s	24.918 n.s	0.150 n.s
Season*Rep	**4**	5.200 n.s	635.417 n.s	546.667 n.s	0.510 **	3.479 n.s	4.433 n.s
Cut	**1**	141.067 **	15.000 n.s	15.000 n.s	383.043**	792.067 **	30.817 *
Season*Cut	**1**	0.600 n.s	1706.667n.s	806.667 n.s	o.726 **	10.141 n.s	1.350 n.s
Rep *Cut* Season	**4**	8.333 n.s	1029.582 n.s	828.333 n.s	0.510 **	3.085 n.s	3.084 n.s
Cultivars	**4**	227.858 **	4330.625 **	4741.042 n.s	5.861 **	14.180 **	14.180 **
Season * Cultivars	**4**	1.308 n.s	80.208 n.s	30.650 n.s	0.088 n.s	1.419 n.s	1.418 n.s
Cut* Cultivars	**4**	324.775 **	1901.458**	1916.042 **	5.862 **	11.186 *	11.186*
Season *Cut* Cultivars	**4**	3.725 n.s	49.375 n.s	43.125 n.s	0.088 n.s	1.129 n.s	1.129 n.s

* and ** Significant and highly significant at 0.05 and 0.01 level of property, respectively, n.s not significant.

At the same time, the interaction between seasons and cutting treatments was not significant for all characters except green forage weight, which was highly significant. The differences among the five barley varieties were highly significant in all studied traits except the number of spikes. m2, which was not significant. For green fodder, a combined analysis of variance demonstrated substantial differences among barley varieties. On the other hand, no significant differences were found for the interactions between varieties and seasons, as well as the interactions between seasons, varieties, and cutting treatments.

Table 2. Mean values of the studied characters for the five barley cultivars as affected by growing seasons.

Season	Plant height (cm)	Number of tillers.m^{-2}	Number of spikes.m^{-2}	Green forage (ton. fed^{-1})	Grain yield (ardab. fed^{-1})	Peduncle length (cm)
First season	105.1	410.5	396.8	3.1	15.8	31.8
Second season	105.3	417.2	412.5	3.3	17.1	31.9
LSD 0.05	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Results in Table 2 revealed that no significant differences were found between the two growing seasons across all studied traits. However, it could be observed slight increases in all traits in the second season.

Table 3. Mean values of the studied characters for the five barley cultivars as affected by cutting treatments.

Treatment	Plant height (cm)	Number of tiller.m^{-2}	Number of spike.m^{-2}	Green forage (ton.fed^{-1})	Grain yield (ardab.fed^{-1})	Peduncle length (cm)
Cut	103.7 b	407.86 a	404.2 a	5.8 a	12.78 b	31.10 b
No cut	106.7 a	405.18 a	405.2 a	0.0 b	20.04 a	32.53 a
LSD 0.05	2.1	N.S.	N.S.	0.5	1.25	1.37

The data in Table 3 showed that cutting treatments had a significant effect on plant height, grain yield, peduncle length, and consequently green forage yield. It was also observed that cutting treatment did not significantly affect both the number of tillers and spikes. m^{-2}, it could be observed that cutting treatment reduced barley grain yield by 7.26 ardab.fed-1 (about 36%).

Table 4. Means of the studied traits for the five barley cultivars over all treatments and seasons.

Cultivars	Plant height (cm)	Number of tillers.m^{-2}	Number of spikes.m^{-2}	Green forage (ton.fed^{-1})	Grain yield (ardab.fed^{-1})	Peduncle length (cm)
Giza 126	103.2 c	430.00 a	421.7 a	3.0 c	16.8 ab	30.92 c
Giza 132	98.8 d	402.50 b	394.2 b	2.9 c	18.2 a	28.67 d
Giza 133	109.8 a	407.50 b	396.3 b	3.7 b	15.8 b	34.75 a
Giza 134	108.3 a	437.08 a	429.2 a	2.4 d	15.6 b	33.25 ab
Giza 2000	103.2 b	392.08 b	382.1 b	4.2 a	15.7 b	31.50 bc
LSD 0.05	2.0	18.37	19.1	0.3	1.6	1.90

Since the aim of the study was to obtain an economical green fodder crop, and then after regrowth, the best barley grain yield would be obtained.

The data presented in Table 4 revealed that barley Giza 2000 gave the highest green fodder yield of 4.2 tons.fed^{-1}, and then after the re-growth the cultivar produced 15.7 ardab.fed^{-1} of barley grains, with a decrease of 2.5 ardab.fed^{-1} than the highest grain yield 18.2 ardab.fed^{-1} produced from the cultivar Giza 132, which gave green fodder only 2.9 tons.fed^{-1} and ranked the last.

Table 5. Interaction effects of cutting treatments and barley varieties on the studied traits over all the two growing seasons.

Treatments	Cultivars	Plant height (cm)	Number of tillers.m^{-2}	Number of spikes.m^{-2}	Green forage (ton.fed^{-1})	Grain yield (ardab.fed^{-1})	Peduncle length (cm)
	Giza 126	93.2 i	439.2 a	430.8 b	5.3 c	13.5 d	30.50 e
Cut	**Giza 132**	98.3 h	394.2 e	384.2 g	5.1 d	13.2 d	23.83 f
	Giza 133	111.0 b	412.5 c	412.5 d	6.7 b	11.5 f	34.33 b
	Giza 134	106.2 e	424.2 b	424.2 c	4.1 e	12.8 d	34.33 b
	Giza 2000	109.7 c	369.2 g	369.2 i	7.6 a	12.8 d	32.50 c
No cut	**Giza 126**	113.2 a	412.5 c	412.5 d	0	19.9 b	31.33 de
	Giza 132	99.30 g	404.2 d	404.2 e	0	23.2 a	33.50 d
	Giza 133	108.7 d	380.0 f	380.0 h	0	20.1 b	35.17 a
	Giza 134	110.3 bc	434.2 a	434.2 a	0	18.4 c	32.17 cd
	Giza 2000	102.2 f	395.0 e	395.0 f	0	18.6 c	30.50 e
LSD 0.05		0.95	8.71	0.18	0.13	0.74	0.9

It is clearly noted from Table 5. That, Giza 132 gave 23.2 ardab.fed^{-1} recording the highest grain yield under normal cultivation conditions (no cutting), followed by Giza 133 and Giza 126 (20.1 and 19.9 ardab.fed^{-1}, respectively).
On the other side, under cutting treatment and regenerated dual purpose barley crop, barley cultivar Giza 126 occupied the top ranking by producing the highest grain yield with 13.5 ardab.fed^{-1}, with a decrease of 32.2% from no cutting and occupied the third ranking for green fodder of 5.3 ton.fed^{-1}. However, barley Giza 132 decreased to 13.2 ardab.fed^{-1} by 56.9% from no cutting and occupied the second ranking. In addition, cultivar Giza 2000 gave the heaviest green fodder recording 7.6 ton.fed^{-1} occupying the first ranking.

DISCUSSION

Barley can be utilized as a source of green fodder and grain yield under rainfed, arid, and semiarid conditions where other strategic cereal and forage crops cannot be grown due to water shortages. So, this existing improved dual barley variety conserves its purpose in specified environments as an alternative for the green forage demand without sacrificing the grain yield in the rainfed, arid, and semi-arid regions of Egypt. The results appeared in Table 1 agreed with the results of Al-Doss and Moustafa (2002), Ghasemi *et al*. (2004) and Singh *et al*. (2017). The mean values located in Table 2 of the studied characters for the five barley cultivars as affected by growing seasons showed results may be due to the high stability of the varieties under study and the change of the conditions due to growing seasons could not affect the characteristics of these varieties (Verma *et al*., 2007).The data presented in Table 3, Pal and Kumar (2010), confirmed that barley grain yield is usually high under no cut treatment, while Jain and Nagar (2010) summarized that cutting barley crop after 45 days from sowing was the ideal time to harvest good grain yield. The significant reductions in plant height, green forage and grain yields and peduncle length may be due to the short period of crop growth after the cutting process (Kaur *et al*., 2009, Hundal *et al*., 2014; Singh *et al*., 2017). It is noticed from Table 4 that the cultivars significantly differed among them in all the studied traits due to their genetic variation Singh *et al*. (2017).

The tallest barley cultivars Giza 133 and Giza 134 were due to the tallest peduncle (Berkesia *et al*.2022; Musavi *et al*., 2012). The two cultivars Giza 126 and Giza 134 produced the greatest number of tillers and spikes.m^{-2} (Noaman *et al*., 2007; El-Bawab *et al*., 2011). The highest yield of green forage produced from the cultivar Giza 2000, and the highest grain yield produced from the cultivar Giza 132 Noaman *et al*. (2007). Previous research proved that there are substantial variations among barley varieties for grain and forage yields (Kaur *et al*., 2009; Hundal *et al*., 2014; Singh *et al*., 2017).

The results presented in Table 5 were in harmony with those of Ahmed *et al*. (2003) who confirmed that Giza 2000 significantly exceeded the checks and combines the good characteristics which including high yielding ability, early maturity, resistant to powdery mildew disease and partially resistant to net blotch, that contribute in high yielding (Noaman *et al*., 2007). Moreover, Giza 132 is widely adapted to Egypt under drought and saline conditions (Noaman *et al*., 2007). Srimali, (2008) and Kharub *et al*. (2013) reported that Fast-growing, high-biomass, early-stage barley is known to have potential as a fodder resource. Consequently, grain yield presented in Table 5 were in harmony with (Noaman *et al*., 1995, Noaman *et al*., 2007 and El-Bawab *et al*., 2011). Noaman *et al*. (1995) proved that barley cultivar Giza 126 has wide ability adaptation, high number of tiller and spikes.m^{-2}. From the previous results, barley cultivar Giza 126 and Giza 2000 were the superior cultivars for dual purpose utilization to produce green fodder and grain yield without a significant decrease. Noaman *et al*. (1995) reported that barley cultivar Giza 126 out yielded the checks due to wide ability adaptation, high number of tiller and spikes.m^{-2}. The interaction results are in harmony with Ahmed *et al*. (2003). They confirmed that Giza 2000 significantly exceeded the checks.

CONCLUSION

It was noticed that one cutting at 55 days after sowing could be a proper stage to harvest green forage as well as grain crops obtained from regenerated dual-purpose barley crops. Since both green fodder and grain can be utilized for animal fodder or feed purposes, the crop can be advantageous over most cereal and forage crops because of its dual utilization and lower water and fertilizer requirements. Despite the fact that no-cut is more inexpensive when there is a lack of feed, barley varieties have the potential for dual-purpose utilization. The findings unmistakably demonstrate that a dual-purpose (forage and feed) barley crop is substantially more advantageous than one planted just for grain reasons in dry regions where green forage is a rare resource. This study recommends Giza 126 and Giza 2000 barley cultivars be grown as dual-purpose barley crop cultures because of their wide ability to adapt, economic grain yield, and green fodder.

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توفر زراعة محاصيل الحبوب ثنائية الغرض الفرصة للتغذية على المحصول كعلف أخضر خلال مراحل النمو الخضرية، مع الحصول على محصول الحبوب في نهاية موسم النمو. أيضًا إمكانية المساعدة في مواجهة التغيرات المناخية مثل مخاطر الصقيع أو الظروف الجافة. كان الهدف من الدراسة هو تحديد فوائد زراعة الشعير ثنائى الغرض فيما يتعلق بأعلاف الماشية، والاستهلاك الآدمى، وتخفيف المخاطر، وما إذا كان يمكن أيضًا استخدام أصناف مختلفة من الشعير للاستخدام ثنائي الغرض. أجريت تجربة حقلية بالمزرعة البحثية لمحطة البحوث الزراعية بالنوبارية بمحافظة البحيرة، مصر باستخدام خمسة أصناف من الشعير خلال موسمى الزراعة المتتاليين 2020/2019 - 2021/2020 للاستخدام ثنائى الغرض. لم تظهر النتائج أية فروق معنوية بين الموسمين. كشفت معاملات الحش عن وجود فروق معنوية وعالية المعنوية في جميع الصفات المدروسة باستثناء صفة عدد الأشطاء وعدد السنابل بالمتر المربع. أظهرت صفة وزن العلف الأخضر تأثيرا عالى المعنوية. فيما يتعلق بالزراعة العادية، كانت الإختلافات بين أصناف الشعير الخمسة عالية المعنوية لجميع الصفات المدروسة باستثناء صفة عدد السنابل بالمتر المربع. أظهر التفاعل بين الأصناف ومعاملة الحش فروق معنوية وعالية المعنوية على مستوى الصفات تحت الدراسة. أظهرت ظروف الزراعة العادية أن جيزة 132 أعطت أعلى محصول للحبوب يليه جيزة 133 ثم جيزة 126. بينما أعطى جيزة 2000 أعلى وزن علف أخضر يليه جيزة 133 ثم جيزة 126 تحت ظروف الزراعة ثنائية الغرض. علاوة على ذلك، في ظل الاستخدام ثنائى الغرض، كان لصنفى الشعير جيزة 126 وجيزة 2000 الأفضلية من خلال إعطائهما أفضل محصول حبوب ومحصول علف أخضر. تعظم هذه الدراسة محاور الإستدامة بانتاج الشعير ثنائى الغرض كمحصول علف أخضر بديل دون التضحية بإنتاج الحبوب في المناطق المطرية والقاحلة وشبه الجافة في مصر.

الكلمات المفتاحية: الشعير، ثنائى الغرض، العلف الأخضر، الحش، محصول الحبوب.