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Agro-economic assessment of intercropping of barley with fenugreek and black cumin

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ABSTRACT

Nowadays, one of the major challenges is ensuring food security. Hence, intercropping is an ecological cropping system approach for increasing production with an increase in net returns per unit. In this regard, two field experiments were arranged in a randomized complete block design (RCBD) during the 2019–2020 and 2020–2021 seasons at the EL-Gemmeza Agricultural Research Station, Gharbia Governorate Barley Department, Field Crops Research Institute, and Agricultural Research Center, Egypt. The study aimed to evaluate the agro-economics of two intercropping systems (barley-fenugreek and barley-black cumin). Treatments for the first system were sole barley, 9 rows of barley + 1 row of fenugreek (9B+1F), 8 rows of barley + 2 rows of fenugreek (8B+2F), 7 rows of barley + 3 rows of fenugreek (7B+3F), 6 rows of barley + 4 rows of fenugreek (6B+4F), and sole fenugreek. while the second were sole barley, 9 rows of barley + 1 row of black cumin (9B+1BC), 8 rows of barley + 2 rows of black cumin (8B+2BC), 7 rows of barley + 3 rows of black cumin (7B+3BC), 6 rows of barley + 4 rows of black cumin (6B+4BC), and sole black cumin. Results showed that barley-studied traits were significantly affected by intercropping fenugreek or black cumin. Although the highest grain yield of 2.30 tons (fed^{-1}) was produced in sole barley, 8B+2F, 6B+4F, 7B+3BC, and 6B+4BC recorded the best trends. Competitive relationships on LER across two seasons tended to increase land usage. In addition, the highest values of total income of 26733 LE (the Egyptian pound) per fed translated into the highest net return of 15501 LE per fed were achieved through intercropping 7B+3BC in the 1st season, followed by 6B+4BC. Thus, the planting system could prove to be more productive and can be successfully performed to attain a higher yield benefit per unit area.

Keywords: Barley, fenugreek, black cumin, intercropping, land equivalent ratio, economic evaluation.

INTRODUCTION

Farmers have always been concerned with producing more food from limited land cultivation and redu cing resource use, as profitability has always been a concern. In this context, intercropping is a crucial part of sustainable agriculture, where two or more crops are planted simultaneously in a field with yields. (Tempesta *et al.,* 2019; Glaze-Corcoran *et al.,* 2020). Intercropping systems that are well-designed can result in a greater benefit per unit area, support the efficient utilization of natural resources, increase biodiversity, control pests, enhance crop productivity, and improve natural soil fertility compared to mono-cropping systems. (Naeem *et al.,* 2012; Altieri *et al.,* 2017; Glaze-Corcoran *et al.,* 2020)

Barley (*Hordeum vulgare L.*) is an important and nutritious cereal crop that could be used for food and feed and cover crop to enhance soil fertility in Egypt (Hayes *et al*., 2003). It is rich in protein, carbohydrates, fat and fibers (Ghanbari *et al*., 2012). In many North African countries, it is the primary source of both human and animal food and can replace wheat as the dominant crop due to its tolerance to drought and salinity (Ewis, 2019).

On the other hand, medicinal plants have the potential to enhance the variety of farming systems, enhance profitability, and contribute more to human health. (Chandrashekara and Somashekarapp, 2016). Fenugreek (*Trigonella foenum-graecum L.*) is considered an annual leguminosea herb, originated in the Eastern Mediterranean region and widely cultivated as a spice and traditional-medicinal plant (Kenny *et al*., 2013). Recently, scientific research has highlighted the numerous health benefits of fenugreek, as well as its antidiabetic, anticarcinogenic, , antioxidant, antihyperlipidemic, antiatherogenic, antianorexic, galactagogue, anti-inflammatory, neuroprotective, antifungal and antibacterial properties (Ouzir *et al.,* 2016). However, Black cumin plant (*Nigella sativa* L.) is an annual aromatic plant forming part of the Ranunculaceae family. It originated in the Mediterranean region and is widely cultivated throughout Europe, the Middle East and Asia. (Aggarwal *et al*., 2008; Al-Sman *et al*., 2017). Egypt is one of the top producers (Sultana *et al*., 2018). Its seeds are reputed and utilized for various purposes, such as diuretic, drug, antiasthmatic, carminative, cough, bronchitis, antiviral, anti-helmintic, galactagogue, antipyretic, carminative and anti-diabetic effects (Schouenberg and Paris,1977; Salem, 2005; Darakhshan *et al*., 2015) and flavouring to bakeries or as a spice. (Kybal,1980). Therefore, this study aimed to evaluate the agro-economic of the intercropping system for barely two different medicinal crops.

Materials and methods

In this experiment, multi-row strips were used to sow barley with Fenugreek and black cumin in EL-gemmeza Agricultural Research Station, Barley Department, Field Crops Research Institute, Agricultural Research Center, Gharbia Governorate during two seasons of 2019/2020 and 2020/2021. The barley variety (Giza 133) and local varieties of fenugreek and black cumin were utilized for two intercropping systems. Three replications with plot size 7m^2 (10 rows × 20 cm x 3.5m) were used for this experiment in Randomized Complete Block Design (RCBD). The barley was planted using a single-row hand drill. Fenugreek and black cumin were cultivated as an intercrop with a single row hand drill. For experiment, the first system was sole barley, 9 rows of barley + 1 row of fenugreek (9B+1F), 8 rows barley + 2 rows of fenugreek (8B+2F), 7 rows barley + 3 rows of fenugreek (7B+3F), 6 rows barley + 4 rows of fenugreek (6B+4F) and sole fenugreek. The second was sole barley, 9 rows of barley + 1 row of black cumin (9B+1BC), 8 rows of barley + 2 rows of black cumin (8B+2BC), 7 rows of barley + 3 rows of black cumin (7B+3BC), 6 rows of barley + 4 rows of black cumin (6B+4BC) and sole black cumin. In both seasons, sowing was done at the beginning of December.

Studied characters:

Random samples for each genotype of each plot were used to collect the data of days to maturity, plant height (cm), spike length (cm), peduncle length (cm), No. of tiller.m^{-2}, No. of spikes m^{-2}, biological yield (ton. fed^{-1}), grainyield (ton. fed^{-1}), Straw yield(ton.fed^{-1}). Moreover, seed yield per feddan (kg) for fenugreek and black cumin was recorded and their fixed oil was extracted according to the A.O.A.C. (1980) method. Seed samples were milled and powdered, and then a 10 g subsample was separated after 24 h and immersed in Soxhlet with 300 CC of diethyl ether solution. The desired solvent was separated from the oil by rotary after 6 hours, and then the oil yield per feddan was calculated.

Statistical analysis:

As suggested by Gomez and Gomez (1984) using “Minitab” computer software package, the collected data was statistically analyzed and utilized the analysis of variance (ANOVA) technique for the RCBD design. Means of treatments were compared using LSD tests at a probability level of 5%.

Competitive relationships and yield advantages:

The following formulas were used to calculate the yield advantages and competitive relationships:

Land equivalent ratio (LER):

It was calculated according to the following formula as described by **Willey and Rao (1980):**

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

*Where, Yaa and Ybb were a pure stand of crop, a (fenugreek or black cumin) and b (barley), respectively. Yab is the intercropped yield of a crop and Yba is the intercropped yield b crop.

Economic evaluations:

Grain yields for barley, fenugreek and black cumin produced from cropping systems were obtained to economically assess intercropping yields relative to sole crops. Total income was calculated according to Sheha *et al*. (2022), and net return was calculated for all treatment in Egyptian pounds (LE) using market prices of barley, fenugreek and black cumin according to the Economic Affairs Sector- Price Bulletin, Ministry of Agriculture and Land Reclamation, Egypt. The barley prices were7500 LE/ton and 8000 LE/ton of grains harvested and 1360 LE/ton,1500 LE /ton of straw in 2020/2021 and 2021/22, respectively, Meanwhile, fenugreek prices were 20000 LE/ton and 22000 LE/ton of grains and 3000LE/ton,3000 LE /ton of straw and black cumin price 75000 LE/ton and 80000 LE/ton of grain in 2019/20 and 2020/21, respectively (Published and unpublished data). Benefit-cost ratio (b/c) = net return/cost calculated according to Wasem *et al.,* (2012).

RESULTS

Mean performance of barley in two seasons:

Different highly significant effects in the intercropping system were shown for barley yield. Data concerning yield and yield components of barley were presented in Table (1). Sole barley has produced more grain yield. In this regard, overall mean values for days to heading showed that the most desirable mean values for earliness were exhibited by 6B+ 4BC (75.3 days and 75 days) in both seasons. On the other hand, in the first season, sole cropping of barley was the latest (80.5 days), whereas 9B+1BC in the second season recorded 79.8 days.

In the first season, there was no significant difference in the days to maturity between the sole culture of barley and intercropping systems. In the second season, 6B+4BC was the earliest one with a value of (115.8 days). On the other hand, 6B+4F were the latest maturity value of 119 days in the second season. Moreover, the obtained results in Table (1) showed that the 8B+ 2BC recorded the highest mean value for plant height being 112.8 cm. While the shortest mean value was recorded by sole cropping of barley (98.75 cm) in the first season. Contrary, no significant differences were observed between sole barley and intercropping systems in the second season.

Concerning the spike length, 8B+2F expressed 8.5 cm in the first season. On the other hand, sole cropping of barley showed the smallest mean value (6 cm) in the same season. Meanwhile, there was no significant distinction between sole cropping barley and other intercropping systems in the second season.

Regarding peduncle length, no significant differences were observed between sole cropping barley and intercropping systems in both seasons. The mean performance of a number of tillers.m^{-2} is shown in Table (1) indicating that, the 8B+ 2F was a superior intercropping system regarding number of tillers.m^{-2} overall in the two seasons. In addition, overall mean values for number of spikes.m^{-2} showed that 8B+ 2F possessed the highest mean values (181.3 and 170.3) in both seasons.

Table 1. Mean estimates of the studied characters for the used barley genotype for the two seasons.

Intercropping systems	HD(day)		MD(day)		PLH		SPL		Ped L	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sole barley	80.5	79.25	117	118.75	98.75	111.75	6	7.5	35	37.25
9B +1F	80.3	78.8	116.5	118	99.5	111.8	7.5	6.3	35.5	38.5
8B +2F	79.8	77.5	115.5	118.8	105.5	113.3	8.5	6.3	35.5	38.8
7B+3F	77	79.5	115	118.0	99.5	106.8	7.3	5.5	35	37.5
6B+4F	78.5	79.5	116.5	119	107.8	109.0	7.0	5.5	36	40.5
9B +1BC	80.3	79.8	115.3	118.8	105.0	111	6.7	6.3	31.8	36.8
8B +2BC	80.3	79.5	116.3	119	112.8	113.5	6.2	5.5	35.5	37.8
7B +3BC	78.5	76	116.3	116.5	99.8	106.8	6.3	6	36.3	36.1
6B+4BC	75.3	75	115.3	115.8	104.3	105.5	7.9	5.8	34.3	36.3
LSD	1.186	0.079	N.S	0.899	4.314	N.S.	0.864	N.S	N.S	N.S

Table 1. Mean estimates of the studied characters for the used barley genotype for the two seasons. (Cont.)

Intercropping systems	No. tiller/m²		No. spike/m²		BY (ton.fed⁻¹)		GY(ton.fed⁻¹)		Straw yield(ton.fed⁻¹)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sole barley	**176**	**182.5**	**165.25**	**169.25**	**4.185**	**5.510**	**1.944**	**2.304**	**2.241**	**3.305**
9B +1F	**185.3**	**178.5**	**171.8**	**158.8**	**3.435**	**4.650**	**1.501**	**1.582**	**1.934**	**3.067**
8B +2F	**191.3**	**190.5**	**181.3**	**170.3**	**4.615**	**5.490**	**2.077**	**2.137**	**2.538**	**3.353**
7B +3F	**175**	**189.3**	**164.8**	**163.3**	**3.645**	**4.350**	**1.252**	**1.342**	**2.393**	**3.007**
6B +4F	**165**	**160.3**	**157**	**141.5**	**3.765**	**4.650**	**1.980**	**1.945**	**1.785**	**2.704**
9B +1BC	**176**	**157.8**	**165.5**	**139**	**4.500**	**3.690**	**1.710**	**1.537**	**2.790**	**2.152**
8B +2BC	**175.5**	**160.5**	**164.8**	**145.3**	**4.480**	**3.585**	**1.440**	**1.881**	**2.603**	**1.447**
7B +3BC	**184.5**	**160.5**	**174.3**	**143.5**	**4.110**	**3.540**	**1.845**	**1.560**	**2.265**	**1.980**
6B+4BC	**176.0**	**179.8**	**166**	**163.5**	**3.255**	**3.285**	**1.425**	**1.395**	**1.830**	**1.890**
LSD	**22.13**	**20.81**	**10.45**	**21.50**	**432.7**	**886.5**	**230.64**	**364.05**	**418.06**	**833.19**

Concerning the biological yield, the scored data in Table (1) showed that the 8B+ 2F possessed the highest mean values in both seasons (4.615 ton.fed^{-1}and 5.490 ton.fed^{-1}, respectively). Sole cropping barely recorded a similar trend in the second season. Furthermore, the scored data in Table (1) showed that the 8B+ 2F possessed the highest mean values of grain yield in both seasons (2.077 ton.fed^{-1}and 2.137 ton.fed^{-1}, respectively). Sole cropping barely recorded a similar trend in the second season. For the straw yield, the 8B + 2F possessed the highest mean values (2.538 ton.fed^{-1} and 3.353 ton.fed^{-1}) in both seasons.

Seed yield of the medicinal plants (kg/fed)

Table 2 revealed that the yield of fenugreek seeds was significantly impacted by different intensities of intercropping. The maximum yield of fenugreek seeds (402.6 and 378.78 kg/fed) for both 1st and 2nd seasons were recorded in sole fenugreek crop followed by 6B + 4F (114 and 111.2). Also, a yield of black cumin seed showed the same trend as fenugreek seed yield when intercropped with barley. The sole black cumin cropping was 252 and 196 kg/fed for both seasons followed by 6B + 4 BC which gave 138 and 133.7 kg/fed in both seasons, respectively.

Table 2. Seed yield of fenugreek and black cumin intercropped with barley (kg/ fed)

Intercropping systems	Yield (Kg/ fed)			
	Fenugreek		Black cumin	
	1st season	2nd season	1st season	2nd season
SOLE crop of medicinal plant	**402.6**	**378.78**	**252**	**196**
9 rows of barley + 1 row of medicinal plant	**28.9**	**25.9**	**18.40**	**30.70**
8 rows of barley + 2 rows of medicinal plant	**41.9**	**34.8**	**42.00**	**48.50**
7 rows of barley + 3 rowsof medicinal plant	**58.80**	**53.8**	**81.10**	**100.6**
6 rows of barley + 4 rowsof medicinal plant	**114.0**	**111.2**	**138.0**	**133.7**
LSD	**9.285****	**241.41****	**20.389****	**21.231****

Oil yield

The data of oil yield for fenugreek and black cumin is shown in Figure (3) which indicates that oil content was significantly affected by the intercropping. In the case of fenugreek, the sole plant gave the highest oil yield (28.3 and 29.29 l/fed) for both seasons and increased by 71% and 73.5% for the intercropping system (6B + 4F). While in the case of black cumin, when the plant was sown alone, an 11.3 % and 10 % increase in oil yield was observed compared to black cumin intercropped with barley (6B + 4 BC) being in the first and second seasons, respectively.

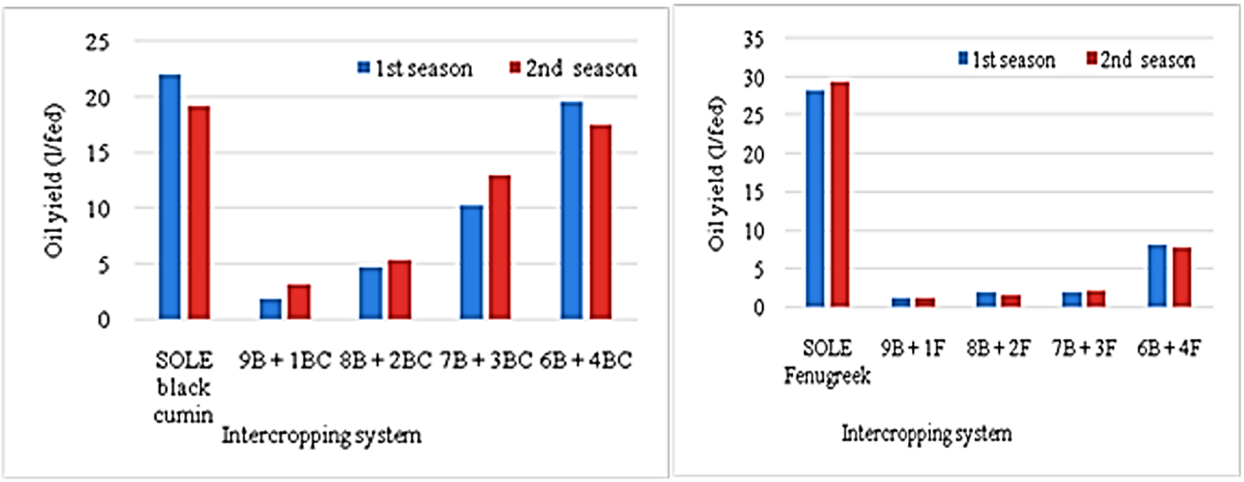

Fig. 1. Oil yield of fenugreek and black cumin seeds intercropped with barley (l/ fed)

Competitive relationships

Land equivalent ratio (LER):

Land equivalent ratio (LER) can be used to determine the effectiveness of each intercropping barely accompanied by the tested fenugreek and black cumin companion crop compared to sole (pure). Calculated values of LER in Table (3) and Fig (2) were increased than one in both seasons by the interaction between barley with intercropping treatments in most cases showed that the LER values of different intercropping systems ranged between 0.79(7B +3F) to 1.30 (6B +4F), respectively in the first season and 0.76(9B +1F) to 1.29 for 6B + 4BC, respectively in the second season. LER values showed that all intercropping systems gave values higher than unit except for 9B +1F, 7B+3F and 9B +1BC in both seasons and 8B +2BC in the 1st season. So, LER results indicated that 8B +2F, 6B+4F, 7B +3BC and 6B+4BC recorded the best systems. Competitive relationships on LER across two seasons tended to increase land usage.

Table 3. Effect of the interaction between barley and aromatic crops on land equivalent ratio (LER) across two seasons

Intercropping systems	Land equivalent ratio (LER)					
	1st season			2nd season		
	RY Barley	RY aromatic	LER	RY Barley	RY aromatic	LER
9B +1F	0.77	0.07	0.84	0.69	0.07	0.76
8B +2F	1.07	0.10	1.18	0.93	0.09	1.02
7B +3F	0.64	0.15	0.79	0.58	0.14	0.73
6B +4F	1.02	0.28	1.30	0.85	0.29	1.14
9B +1BC	0.88	0.07	0.95	0.67	0.16	0.82
8B +2BC	0.74	0.17	0.91	0.82	0.25	1.07
7B +3BC	0.95	0.32	1.27	0.68	0.51	1.19
6B +4BC	0.73	0.55	1.28	0.61	0.68	1.29

RY: relative yield = intercrop yield/sole yield

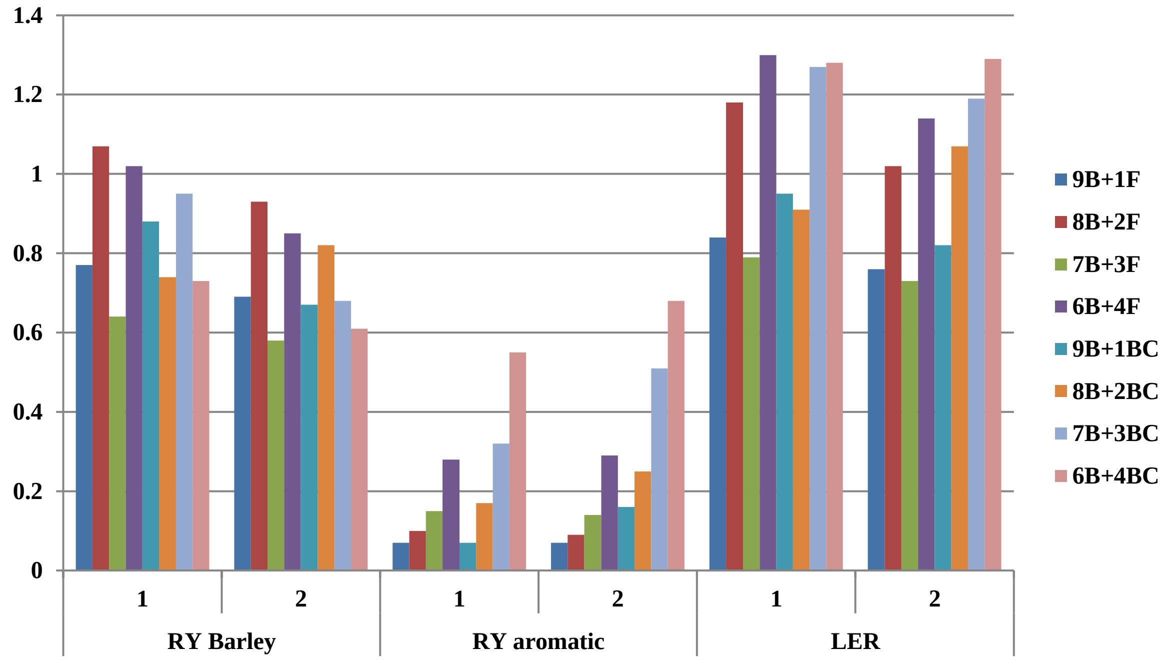

Fig. 2. RY Barley,RY aromatic and LER values of different intercropping treatments in both seasons.

ECONOMIC EVALUATION

Total income:

Data presented in table (4) indicated that in the 1st season, the highest value of total income is 26733 LE/fed achieved by the intercropping system of 7B+3BC followed by total income under 6B+4BC (25050 LE/fed). While, in the second season, it was indicated that the intercropping system of 8B+2F gave the highest value for the total income for barley and aromatic yields being 24240 LE/fed followed by 24194 LE/fed recorded by intercropping system 6B+4F.

Table(4). Economic evaluation of barley and different levels of intercropping of fenugreek and black cumin practices across seasons

Intercropping systems	Income grain (pound.fed^{-1})		Income Straw (pound.fed^{-1})		Income barley(pound.fed^{-1})		Income aromatic yield		Total income (pound.fed^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sole barley	14580	18432	3048	4958	17628	23390	-	-	17628	23390
Solefenugreek	-	-	-	-	-	-	14539	16299	14539	16299
Soleblack cumin	-	-	-	-	-	-	23736	20056	23736	20056
9B +1F	11257	12656	2630	4601	13888	17257	1210	1529	15098	18786
8B +2F	15577	17096	3452	5030	19029	22126	1971	2114	21000	24240
7B +3F	9390	10736	3254	4511	12644	15247	3159	3515	15803	18762
6B +4F	14850	15560	2428	4056	17278	19616	6943	4578	24221	24194
9B +1BC	12825	12296	3794	3228	16619	15524	1411	4312	18030	19836
8B +2BC	10800	15048	3540	2171	14340	17219	2064	2996	16404	20215
7B +3BC	13837	12480	3080	2970	16918	15450	9815	6372	26733	21822
6B+4BC	10687	11160	2489	2835	13176	13995	11874	7287	25050	21282

Results exhibited that the highest values of total income 26733 LE/fad reaching the highest net return 15501 LE/fad resulted from (7B+ 3BC) in the 1stseason, followed by total income under(6B+4BC)total income 25050 LE/fed was attained the highest net return 14989 LE/fad in the 2nd season, followed by total income under (8B + 2F) treatment

24240 LE/fad followed by (6B + 4F) 24194 LE/ fad, the highest net return 11040 LE/fad , follow by 10994 LE/fad under (8B+ 2F) and under (6B + 4F), respectively.

Total cost, Net return and Benefit-cost ratio (b/c):

Data in (Table 5) showed that the total cost of sole barley were 12200 and 13100 LE/fed, in the 1st and 2nd season, respectively. While, the cost of sole fenugreek were 10120 and 10500 LE/fed in the 1st and 2nd season, respectively, and the cost of sole black cumin were 11230 LE/ fed, 12950 LE/fed, in both seasons. On the other hand, the highest total costs (11300 and 13200 LE/fed) were recorded in barley and fenugreek in both seasons.

Data presented in Table (5) revealed that 7B+3BC and 6B + 4BC systems achieved the best net return in the 1st season being 15501 LE/fed and 13818 LE/fed, followed by 12921LE/fed given by 6B + 4F. In the second season, the highest values of net return recorded were 11040 and 10994 LE/ fed under the intercropping system of 8B + 2F and 6B + 4F, respectively.

The highest values of benefit/cost ratio 1.38 and 1.23 were recorded in the first season under 7B +3BC and 6B + 4BC systems, respectively. In the 2nd season, the highest benefit/cost ratio was obtained by 8B +2F and 6B +4F systems being 0.84 and 0.83. On the other hand, the minimum values of benefit/cost ratio were obtained under 9B + 1F and 7B +3F recording 0.34 and 0.40 in 1st season and 0.42 and 0.42 in the 2nd season, respectively.

Table 5. Economic evaluation of barley and different levels of intercropping of fenugreek and black cumin (Net return and benefit-cost ratio) across seasons

Intercropping systems	Total cost (Pound.fed^{-1})		Net return (Pound.fed^{-1})		Benefit-cost ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sole barley	12200	13100	5428	10290	0.44	0.79
Solefenugreek	10120	10500	4419	5799	0.44	0.55
Soleblack cumin	11230	12950	12506	7106	1.11	0.55
9B +1F	11300	13200	3798	5586	0.34	0.42
8B +2F	11300	13200	9700	11040	0.86	0.84
7B +3F	11300	13200	4503	5562	0.40	0.42
6B +4F	11300	13200	12921	10994	1.14	0.83
9B +1BC	11232	13118	6798	6718	0.61	0.51
8B +2BC	11232	13118	5172	7097	0.46	0.54
7B +3BC	11232	13118	15501	8704	1.38	0.66
6B+4BC	11232	13118	13818	8164	1.23	0.62

DISCUSSION

In this study, the increase in LER refers to the benefits of intercropping versus sole crop in terms of yield and economy. The increase in LER can indicate that inputs are being utilized effectively, such as water and fertilizer, as well as other resources including land, labor and light (Sarkar and Chakraborty, 2000; Sarkar *et al*., 2001). Moreover, many researchers have observed the advantages of inter-cropping. (Hinsinger *et al*., 2011; Zhang *et al*., 2014, Moghaddam 2016 and Bitarafan *et al*., 2019). The high barley yield components; the number of tillers and number of grains per spike in barley was observed in sole sown, compared to other intercropping systems (Naeem *et al*., 2013). Marked reduction in barley biological yield in all intercropping systems has been measured due to a smaller number of productive tillers, a similar study was conducted by Wahla *et al.,* (2009) in barley based on cropping systems. Studying the production system efficiency can be evaluated based on its economic analysis. The intercropping systems of 8 rows of barley +2 rows of fenugreek, 6 rows of barley + 4 rows of fenugreek, 7 rows of barley +3 rows of black cumin, and 6 rows of barley +4 rows of black cumin noted to be the highest total variable cost. Abu-Bakar *et al.* (2014) stated that the variations in net benefits amongst the numerous intercropping systems can be associated to the current market prices of the different crops cultivated as intercrops, which vary from crop to other and even between the diverse varieties in the same crop. On the other hand, it was observed that intercropping barely with fenugreek is much effective to all barley studied characters in this study than black cumin, this may be due to the benefits of legume-based intercropping especially caused by the legumes ability to fix biological nitrogen (Fan *et al.,* 2006), increase bioavailability of soil phosphorus (Sas *et al.,* 2001), and it can be a nutrient supporter that delivers nutrients to the other non-legume throughout root exudates or by the arbuscular mycorrhizal fungi hyphal system (Hauggaard *et al.,* 2003; Hauggaard *et al.,* 2006; Hauggaard *et al.,* 2009; Hauggaard *et al.,* 2009a; Knudsen *et al.,* 2004; Li, *et al*., 2009; Li, Yu *et al*., 2009; Tosti and Guiducci 2010). Overall, intercropping strategy has the prospective to overcome food security and food diversity challenges with reduced resources.

CONCLUSION

In terms of LER, it could be accomplished that cultivated barley intercropping is much better than cultivated as sole cropping. Moreover, the barley and medicinal plant intercropping system could be successfully applied, as it gives a highest yield per feddan than the other treatments in current investigation. So, farmers can adopt 8 rows of barley + 2 rows of fenugreek, 6 rows of barley + 4 rows of fenugreek, 7 rows of barley + 3 rows of black cumin, and 6 rows of barley + 4 rows of black cumin intercropping systems. This is to expansion production and to meet the domestic demand for fenugreek or black cumin. This will be an innovative strategy for food diversification. Further research is needed in this direction in vireo locations before wide-scale determination by farmers.

References

Abu Bakar, M. U., R. H. Ehsanullah, & Z. A. Zahir. (2014). Comparison of barley-based intercropping system for productivity and net economic return. *International Journal of Agriculture and Biology,* 16(6), 1183-1188.

Aggarwal, B. B., Ajaikumar B. Kunnumakkara, Kuzhuvelil B. Harikumar, Sheeja T. Tharakan, Bokyung Sung, & Preetha Anand. (2008). Potential of spice-derived phytochemicals for cancer prevention. *Planta Medica*, 74, 1560-1569.

Al-Sman K. M., Abo-El-yousr A. M. Kamal, Eraky Amal, & El-Zawahry Aida. (2017). Isolation, identification and bio-management of root rot of black cumin (*Nigella sativa*) using selected bacterial antagonists. International *Journal of Phytopathology,* 6, 47-56.

Altieri, M. A., Clara I. Nicholls, & Rene Montalba. (2017). Technological approaches to sustainable agriculture at a crossroads: An agroecological perspective. Sustainability, 9, 349.

Bitarafan, Z., S. M. Jensen, F. Liu, & C. Andreasen. (2019). Intercropping fenugreek (*Trigonella foenum-graecum* L.) and barley (Hordeum vulgare L.) with and without biochar: Tests along a competition gradient. *Journal of Agronomy and Crop Science,* 205, 99-107.

Chandrashekara, K., & H.M Somashekarappa. (2016). Estimation of radionuclides concentration and average annual committed effective dose due to ingestion for some selected medicinal plants of South India. *Journal of Radiation Research and Applied Sciences,* 9, 68-77.

Darakhshan, S., R. Tahvilian, & A. Colagar. (2015). Nigella sativa: A plant with multiple therapeutic implications. *International Journal of Pharmacognosy*, 2, 190-214.

Ewis, A. M. G. (2019). Evaluation the effect of N mineral fertilization in combination with N biofertilizer on barley yield and its components in sandy soil. *Journal of Soil Sciences and Agricultural Engineering,* 10(8), 423-433.

Fan, F., Fusuo Zhang, Yana Song, Jianhao Sun, Xingguo Bao, Tianwen Guo, & Long Li. (2006). Nitrogen fixation of faba bean (*Vicia faba* L.) interaction with a non-legume in two contrasting intercropping systems. *Plant and Soil,* 283, 275-285.

Ghanbari, A., M. Babaeian, Y. Esmaeilian, A. Tavassoli, & A. Asgharzade. (2012). The effect of cattle manure and chemical fertilizer on yield and yield component of barley (Hordeum vulgare). *African Journal of Agricultural Research,* 7(3), 504-508.

Glaze-Corcoran, S., Hashemi, M., Sadeghpour, A., Jahanzad, E., Afshar, R. K., Liu, X., & Herbert, S. J. (2020). Understanding intercropping to improve agricultural resiliency and environmental sustainability. *Advances in Agronomy,* 162, 199-256.

Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research (2nd ed.). John Wiley & Sons.

Hauggaard-Nielsen, H., Ambus, P., & Jensen, E. S. (2003). The comparison of nitrogen use and leaching in sole cropped versus intercropped pea and barley. *Nutrient Cycling in Agroecosystems,* 65, 289-300.

Hauggaard-Nielsen, H., Andersen, H., Jornsgaard, B., & Jensen, E. S. (2006). Density and relative frequency effects on competitive interaction and resource use in pea-barley intercrops. *Field Crop Research,* 95, 256-267.

Hauggaard-Nielsen, H., Gooding, M., Ambus, P., Corre-Hellou, G., Crozat, Y., Dahlmann, C., Dibet, A., Fragstein, P. V., Pristeri, A., Monti, M., & Jensen, E. S. (2009a). Pea-barley intercropping for efficient symbiotic N2-fixation, soil N acquisition and use of other nutrients in European organic cropping systems. *Field Crop Research*, 113(1), 64-71.

Hauggaard-Nielsen, H., Gooding, M., Ambus, P., Corre-Hellou, G., Crozat, Y., Dahlmann, C., ... Jensen, E. S. (2009b). Pea-barley intercropping and short-term subsequent crop effects across European organic conditions. *Nutrient Cycling in Agroecosystems,* 85, 141-155.

Hayes, P. M., Castro, A., Cedillo, L. M., Corey, A., Henson, C., Jones, B. L., Kling, J., Matus, D., Rossi, I. I., & Sato, K. (2003). Genetic diversity for quantitatively inherited agronomic and malting quality traits. In Diversity in Barley (Hordeum vulgare) (pp. 159-183). Elsevier Science Publishers.

Hinsinger, P., Betencourt, E., Bernard, L., Brauman, A., Plassard, C., & Shen, J. (2011). P for two, sharing a scarce resource: soil phosphorus acquisition in the rhizosphere of intercropped species. *Plant Physiology,* 156, 1078-1086.

Kenny, O., Smyth, T. J., Hewage, C. M., Brunton, N. P. (2013). Antioxidant properties and quantitative UPLC-MS analysis of phenolic compounds from extracts of fenugreek (*Trigonella foenum-graecum*) seeds and bitter melon (*Momordica charantia*) fruit. *Food Chemistry,* 141(4), 4295-4302.

Knudsen, M. T., Hauggaard-Nielsen, H., Jornsgaard, B., & Jensen, E. S. (2004). Comparison of interspecific competition and N use in pea-barley, faba bean-barley and lupin-barley intercrops grown at two temperate locations. *Journal of Agricultural Science,* 142, 617-627.

Kybal, J. (1980). Herbs and spices. The Publishing Corp Limited.

Li, Y. F., Ran, W., Zhang, R. P., Sun, S. B., & Xu, G. H. (2009). Facilitated legume nodulation, phosphate uptake and nitrogen transfer by arbuscular inoculation in an upland rice and mung bean intercropping system. *Plant and Soil, 3*15, 285-296.

Li, Y., Chang-Bin, Y., Cheng, X., Li, C., Sun, J., Zhang, F., Lambers, H., & Li, L. (2009). Intercropping alleviates the inhibitory effect of N fertilization on nodulation and symbiotic N2 fixation of faba bean. *Plant and Soil,* 323, 295-308.

Moghaddam, A. N. (2016). Effect of nitrogen and different intercropping arrangements of barley (Hordeum vulgare L.) and pea (Pisum sativum L.) on forage yield and competitive indices. Journal of Agroecology, 8(1), 47-58.

Naeem, M., Cheema, Z. A., Ahmad, A. U. H., Wahid, A., Farooq, O., & Rehman, H. S. U. (2013). Agroeconomic assessment of wheat (*Triticum aestivum*) canola (Brassica napus) intercropping systems under different spatial patterns. International Journal of Agriculture and Biology, 15, 1325-1330.

Ouzir, M., El Bairi, K., & Amzazi, S. (2016). Toxicological properties of fenugreek (*Trigonella foenum-graecum*). Food and Chemical Toxicology, 96, 145-154.

Salem, M. L. (2005). Immunomodulatory and therapeutic properties of the Nigella sativa L. seed. *International Immunopharmacology*, 5, 1749-1770.

Sarkar, R. K., & Chakraborty, A. (2000). Biological feasibility and economic visibility of intercropping pulse and oil seed crop sesame (Sesame indicum) under different planting patterns in rice-fallow genetic alluvial land. *Indian Journal of Agricultural Sciences,* 70(4), 211-214.

Sarkar, R. K., Saity, K., & Kundu, C. (2001). Sustainable intercropping system of sesame (Sesame indicum) with pulse and oil seed crops on rice-fallow land. *Indian Journal of Agricultural Sciences,* 71(2), 90-93.

Sas, L., Rengel, Z., & Tang, C. (2001). Excess cation uptake, and extrusion of protons and organic acid anions by Lupinus albus under phosphorus deficiency. *Plant Science,* 160(6), 1191–1198.

Schouenberg, P., & Paris, F. (1977). Guide to Medicinal plants. Lutterworth Press Grildfard and London, England, 205.

Sheha, A. M., Mansour, M., Ebrahim, S. A., El-Gamal, I. S. H., & Ghareeb, Z. E. (2022). Agro-economical Evaluation for Intercropping Sugar Beet and Barley under Combinations of Barley Cutting and Nitrogen Level Treatments. International Journal of Plant and Soil Science, 34(18), 174-190. Article no. IJPSS.86566 ISSN: 2320-7035

Sultana, S., Das, B., Rudra, B. C., Das, G., & Alam, M. B. (2018). Effect of date of sowing on productivity of black cumin. *International Journal of Current Microbiology and Applied Science,* 7, 1796-1800.

Tosti, G., & Guiducci, M. (2010). Durum wheat-faba bean temporary intercropping: Effect on nitrogen supply and wheat quality. *European Journal of Agronomy, 33*, 157–165.

Wahla, I. H., Ahmad, R., Ehsanullah, A., Ahmad, A., & Jabbar, A. (2009). Competitive function of components crops in some barley based intercropping system. International Journal of Agriculture and Biology, 11(1), 69-72.

Willey, R. W., & Rao, M. R. (1980). A competitive ratio for quantifying competition between intercrops. *Expl. Agric.,* 17, 257-264.

Zhang, X., Huang, G., & Zhao, Q. (2014). Differences in maize physiological characteristics, nitrogen accumulation, and yield under different cropping patterns and nitrogen levels. *Chilean Journal of Agricultural Research,* 74(3), 326-332.

التقييم الاقتصادي الزراعي لنظام الزراعة المتداخلة بين محصول الشعير ونباتي حبة البركة والحلبة

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تعتبرالزيادة السكانية مع انخفاض المتاح من الموارد الزراعية من التحديات الكبرى التي تواجه لأمن الغذائي.لذلك، يعد التوجه الى نظام الزراعة المتداخلة (التكثيف الزراعي) من انماط الزراعةالتي يمكن اتباعها لزيادة الإنتاج من خلال زيادة صافي العائد من وحدة الارض. في هذا الصدد،فانه خلال موسمي 2020/2019 و2021/2020، تم إجراء دراسة حقلية في محطة البحوث الزراعية بالجميزة بمحافظة الغربية التابعةلقسم الشعير بمعهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية. حيث استهدفت التقييم الاقتصادي الزراعي للزراعة المتداخلة بين محصول الشعير وكل من محصولي النباتات الطبية والعطرية "حبة البركة والحلبة. تم تصميم الدراسة التجريبية مشتملة القطاعات العشوائية الكاملة، بما في ذلك تقييم زراعة الشعير مع الحلبة وتقييم زراعة الشعير مع حبة البركة. وقد تألفت الدراسة من المعاملات التالية: الشعير منفرد 20 سم 10صفوف متباعد، 9 صفوف شعير + صف واحد حلبة، 8 صفوف شعير + 2 صفوف من الحلبة، 7 صفوف شعير + 3 صفوف من الحلبة، 6 صفوف شعير + 4 صفوف من الحلبة وحدها على التوالي. 9 صفوف من الشعير + صف واحد من حبة البركة، 8 صفوف من الشعير + صفان من حبة البركة، 7 صفوف من الشعير + 3 صفوف من حبة البركة،و6 صفوف من الشعير + 4 صفوف من حبة البركةوحبة البركةوحده، على التوالي.كما أظهرت النتائج أن مكونات النمو والمحصول للشعير مثل طول النبات، وطول السنبلة، وعدد الحبوب في السنبلة، ووزن الألف حبة، والمحصول البيولوجي، ومحصول الحبوب تأثرت معنوياً بزراعة نبات الحلبة أو حبة البركة. على الرغم من أن أعلى إنتاجية للحبوب وقدرها 2.30 (طن /فدان -1) تم إنتاجها في الشعير المزروع بمفرده، إلا أنه بناءً على معدل تنافس الارض، فإن معظم أنظمة الزراعة البينية أسفرت عن فائدة أكبر من المحصول المنفرد لأي من المحصولين. إجمالاً، أشارت نتائج LER إلى أن 8 صفوف من الشعير + 2 صفوف من الحلبة،و6 صفوف من الشعير + 4 صفوف من الحلبة،و7 صفوف من الشعير +3 صفوف من حبة البركة،و6 صفوف من الشعير + 4 صفوف من حبة البركة من أفضل المعاملات التي تم تسجيلها.. تميل العلاقات التنافسية على LER عبر موسمين إلى زيادة استخدام الأراضي. أوضحت النتائج أن أعلى قيم لإجمالي الدخل 26733 جنيه / فدان محققة أعلى صافي عائد 15501 جنيه / فدان نتجت عن الزراعة المتداخلة بين 7 صفوف من الشعير مع 3 صفوف من حبة البركة في الموسم الأول، يليها الزراعة المتداخلة بين 6 صفوف من الشعير + 4 صفوف من حبة البركة التي حققت اجمالي دخل فدان 25050 جنيه مع صافي عائد 14989 جنيه. اما الموسم الثاني تأتي الزراعة المتداخلة بين 8 صفوف شعير + 2 صفوف من الحلبة محققةإجمالي الدخل للفدان ٢٤٢٤٠جنيه يليها (6 صفوف شعير + 4 صفوف من الحلبة محققة٢٤١٩٤جنيه / فدان. في حين ان اعلي صافي عائد تم تسجيله (11040 جنيه / فدان) تحت الزراعة المتداخلة بين 8 صفوف شعير + 2 صفوف من الحلبة في الموسم الثاني ، يليه تم تسجيل 10994 جنيه / فدان كصافي عائد للزراعة المتداخلة بين (6 صفوف من الشعير + 4 صفوف من حبة البركة). لذا فانه يمكن تطبيق نظام الزراعة المتداخلة كأحد النظم الزراعية لزيادة الإنتاجية من وحدة المساحة.

الكلمات المفتاحية: الشعير ، الحلبة ، الكمون الأسود ، الزراعة البينية ، نسبة الأرض المكافئة ، التقييم الاقتصادي.