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Evaluation of wheat and lentils mixed cropping based on land equivalent ratio and monetary advantage

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ABSTRACT

Field experiment on agro-economic relationship of component crops in a lentils wheat mixed cropping system was conducted during the winter season of 2012 at the Al-Shalalat village which located at the eastward longitude (43º.12"03.64) and northward latitude (36º.28"04.40), Mosul city, Nineveh province of Iraq. The objective of the study were to study the effects of mixed cropping system on the yield and yield components of wheat and lentils and to investigate the best combination and efficiency of resource utilization by determining land equivalent ratio (LER). Mixed cropping resulted in reduced yields and yield components of both wheat and lentils as compared to sole cropping. Further results showed that the highest Land equivalent ratio (LER) for total grain and straw yields were observed in the mixed cropping treatment of Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1}).The highest net income, which provides an appropriate economic assessment of mixed cropping in terms of increased value per unit land, was obtained from Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1}) Treatment.

Keywords: *wheat, lentils, mixed cropping, LER, monetary advantage.*

INTRODUCTION

Nineveh province (which is the wheat growing area of Iraq) are part of North Iraq and includes the jizerah , uplands , foothills and the mountains . The parent materials of the soils of the uplands and the mountain regions were limestone with the exception of the upper jizerah and area bordering the lower Mesopotamian plain where gypsum, mudstone and sandstone were the parent materials. The soils in Nineveh province are alkaline with pH values between 7.6 – 8.2 and with high calcium carbonate (Buring, 1960; Alnuaimi, 1977). The major factors lowering cereal productivity in many agricultural areas in Nineveh province are the combination of high soil pH, $CaCO_3$ and heavy soil texture together with low levels of organic matter and soil moisture (Arid and semiarid land farming). Urbanization and industrialization due to the global population explosion decrease gradually the cultivable area, which facing pressure to meet basic demands for food especially in the developing countries of Asia and Africa .Therefore, there is need for not only increase production, but also the ability to grow multiple crops in small areas. Mixed cropping system which define growing two or more species or cultivars on the same piece of land during the same season is known to increase the size and stability of yields through the effective utilization of natural resources **(**Hauggaard–Nielsen, 2006; Li,1999 and 2001; Zhang and Li., 2003**)** compared to mono cropping. It is used in many parts of the world for the production of food and feed crops to share the food demand which is one of the of the most important

problems of the world is enduring nowadays, improvement of soil fertility through the addition of nitrogen by fixation and extraction from the component legume and increasing the availability of nutrients in the soil rhizosphere (Hauggaard-Nielsen, 2001). Also intercropping of cereals with legumes has been popular in rain-fed areas of the world due to its low cost of production and high monetary returns to the farmers (Ofori and Stern, 1987), improving yield stability, socio-economic and some other advantages (Willey, 1979). In view of this, there is need for not only increase production, but also the ability to grow multiple crops in small areas. One parameter such as land equivalent ratio (LER) has been used to assess the efficiency of mixed crops. However, LER is considered as the most appropriate in combination with the absolute yields of the crops. In this research the wheat and lentils mixed crops was tested in regard to grain and straw yields compared to sole cropping. Thus the aim of our study to determine the best combination and efficiency of resource utilization by determining land equivalent ratio (LER).

MATERIALS AND METHODS

Crop management and experimental design

Field experiment was conducted during 2012 in a private farm in Al-Shalalat village [locate at the eastward longitude (43º.12"03.64) and northward latitude (36º.28"04.40)] which belongs to Mosul city, Nineveh province of Iraq. The topsoil (0–0.3m) of the experimental field (table-1) which classified within the order Aridisols and Calciorthid great group was a clay loam with a composition of 452, 450 and 90 g kg^{-1} clay, silt and sand respectively. The pH of the soil was 7.83. The air-dried soil contained 56 mg kg^{-1} available N, 20.4 g kg^{-1}organic matter and 370 g kg^{-1} $CaCO_3$.The experiment was arranged as a factorial based on randomized complete block design (split plot) with three replications. The following treatments were used :

T1 : Sole wheat (100 kg ha^{-1}) + (0.0 kg ha^{-1}) Lentils
T2 : Wheat (100 kg ha^{-1}) + (20 kg ha^{-1}) Lentils
T3 : Wheat (100 kg ha^{-1}) + (40 kg ha^{-1}) Lentils
T4 : Wheat (100 kg ha^{-1}) + (60 kg ha^{-1}) Lentils
T5 : Wheat (100 kg ha_{-1}) + (80 kg ha^{-1}) Lentils
T6 : Sole Lentils (0.0 kg ha^{-1}) wheat + (80 kg ha^{-1}) Lentils

Six blocks were used, each block size was 3.6 m×100 m involving 20 rows with inter–row spacing of 18 cm and inter-block spacing of 1.5 m. Seed bed preparation included ploughing, disk harrowing and cultivation. Seed rate used for wheat was 100 kg ha^{-1} and 80 kg ha^{-1} for lentils. Irrigation water was provided when needed using sprinkler irrigation. After harvest and in order to evaluate the competitive effects among component crops and to determine mixed cropping performance in mixture and sole crop, different indices as grain and straw yields of both wheat and lentils of each treatment were calculated. The most basic tool that agricultural scientists generally use to evaluate mixed crop efficiencies in grain and straw yields, of a crop with respect to sole crops is the land equivalent ratio (LER). In particular, LER verifies the effectiveness of mixed cropping for using the resources of the environment compared to sole cropping (Mead and Willey, 1980; Dhima, 2007). When LER is greater than 1, the mixed cropping favors the growth and yield of the species. In contrast, when LER is lower than 1, the mixed cropping negatively affects the growth and yield of plants grown in mixtures (Ofori and Stern, 1987; Caballero, 1995; Dhima et al., 2007). LER values was calculated according to Willey (1979) using the following formula: LER = (LER wheat + LER lentils), where LER wheat = (Ywm /Yws), and LER lentils = Ylm / Yls, where Yws and Yls are the yields of wheat and lentils as sole crops, respectively, and Ywm and Ylm are the yields of wheat and lentils as mixed crops, respectively.

RESULTS AND DISCUSSION

Physicochemical characteristic of soil

Various physical and chemical properties of soil are presented in table (1). Soil had high pH (7.83) and was calcareous, which contain more than 365 g kg^{-1} $CaCO_3$. The organic matter content was 20.4 g Kg^{-1} soil. Soil had a clay loam texture, where the clay fraction was almost equal to that of silt. The high pH and the high concentrations of $CaCO_3$ and clay in soil together with low annual precipitation can be considered to be the major factors causing deficiency of the most nutrients specially micronutrients in plant grown in the north part of Iraq. Nutrients moves to plant root in soils is limited largely by

diffusion and mass flow in the soil solution (O'Connor, 1971; Chaney, 1984; Marschner, 1993), and thus absorption is highly dependent on soil water status and root growth (Mengel and Kirkby, 2001).

Table 1. Physiochemical properties of top soil sample (0 – 0.3m)

1	Electrical conductivity EC (ds m^{-1}) from 1:1 extract	0.57
2	Soil pH from 1:1 soil suspension	7.83
3	Total Calcium carbonate(g kg^{-1})	370
4	Organic matter (g Kg^{-1})	20.4
5	Sand (g Kg^{-1})	98
6	Silt (g Kg^{-1})	450
7	Clay (g Kg^{-1})	452
8	Soil texture	Clay loam
	Micronutrients (DTPA)	
9	Available Fe (mg Kg^{-1} soil)	2.8
10	Available Zn (mg Kg^{-1} soil)	0.6
11	Available Mn (mg Kg^{-1} soil)	5.0
12	Available Cu (mg Kg^{-1} soil)	3.0
	Macronutrients	
13	Available Nitrogen (mg Kg^{-1})	56
14	Available phosphorous (mg Kg^{-1})	4.6
15	Available Potassium (mg Kg^{-1})	355.6

Yield and yield component of crops

In wheat, highest performance on plant height, spikes m^{-2}, No. of seed $spike^{-1}$ and 1000 seeds weight (Table-2) were achieved in sole treatment (T1) as compared to mixed cropping treatments (T2,T3,T4 and T5). In case of lentils also the highest plant height (Table-3) was achieved in sole treatment (T6). Therefore, this reduction in yield components of both crops in response to mixed cropping was reflected on the grain and straw yields of wheat (Table-4) and lentils crops (Table-5), where the highest wheat yield (1.78 t ha^{-1}) was obtained in sole treatment (T1) which was followed by T2 (1.63 t ha^{-1}),T3 (1.75 t ha^{-1}),T4 (1.25 t ha^{-1}) and the lowest yield (0.98 t ha^{-1}) was obtained from T5. For lentils the highest yield (0.67 t ha^{-1}) was in T6 (sole treatment) which was followed by T5 (0.47 t ha^{-1}), T4 (0.42 t ha^{-1}), T3 (0.41 t ha^{-1}) and the lowest (0.26 t ha^{-1}) was in T2. Yields reduction in mixed cropping treatments of both crops might be due to the higher competition for moisture, space, light and nutrition among the crop plants, also wheat might had shading effect on lentils (Akter, 2004). These results agrees with the finding of (Yağmur and Kaydan, 2006). The highest grain yield of lentils by mixed cropping treatment (T5) as compared to the other mixed cropping treatment (T4, T3 and T2) could result from higher population/unit area which result from the highest seed sowing density of lentils (Çiftçi and Űlker,2005).

Land Equivalent Ratio (LER)

LER is used frequently as index of biological advantage, which places the component crops on a relative and directly comparable basis (Willey,1979). It is defined as the relative land area that would be required for sole crops to produce the yields achieved in mixed cropping. In particular, LER verifies the effectiveness of mixed cropping for using the resources of the environment compared to sole cropping (Mead and Willey, 1980; Dhima et al., 2007). When LER is greater than 1, the mixed cropping favors the growth and yield of the species. In contrast, when LER is lower than 1, the mixed cropping negatively affects the growth and yield of plants grown in mixtures (Ofori and Stern, 1987; Caballero et al., 1995; Dhima et al., 2007). Land equivalent ratio (LER) of the total grain yield of both wheat and lentils crops varied from 1.25 to 1.59 (Table- 6). Highest LER (1.59) was observed in case of Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1}). For total straw yield the highest LER (which varied from 1.12 to 1.45) 1.45 was observed in case of Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1}) also. By contrast, the minimum LER (1.00) of both yields were recorded in case of sole wheat and sole lentils (wheat and lentils alone).

Combined yield and Net income

The highest combined grain (2.16 t ha^{-1}) and straw (1.98 t ha^{-1}) yields of wheat and lentils were found in T3 Treatment [Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1})], and it were significantly higher than that of the sole wheat crop (T1) and the sole lentils crop (T6). Similar result was obtained by Singh et al. (1996), who reported that the combined yield of wheat and lentils under wheat-lentils intercropping system was significantly higher than that of the sole crop. The monetary advantage (Table-7) of wheat and lentils was influenced by mixed cropping system. The highest net income, (2468128.0 Iraqi Dinar = 2431.0 US $) which provides an appropriate economic assessment of mixed cropping in terms of increased value per unit land, was obtained from T3 Treatment. The treatment T1 [Sole wheat (100 kg ha^{-1}) + 0.0 kg ha^{-1} Lentils] showed the lowest net income (1411661.0 Iraqi Dinar =1212.8 US $), Similar result was also found by Singh et al. (1996) who stated that the monetary advantage evaluated over the sole wheat indicated a positive gain from intercropping system. They tested wheat + lentils

intercropping and found that maximum monetary advantage was recorded from wheat + lentils in 3:1 row ratio followed by 1:1 row ratio. Ahmad (1989) also reported additional economic benefits in different intercropping systems. The results led to the conclusion that although the wheat and lentils grain and straw yields were reduced by mixed cropping system but at the end the net income of both crops was compensated more than the losses in lentils or wheat alone.

Table 2. Effect of mixed cropping wheat with lentils on wheat yield components

Treatment	Plant height (cm)	No. of spikes m^{-2}	No. of seeds $spike^{-1}$	1000-seed weight
T1: Sole wheat	68.00	178.24	29.92	24.02
T2: Wheat100% + lentils 25%	56.00	146.00	23.67	22.44
T3: Wheat100% + lentils 50%	55.00	168.00	23.25	23.09
T4: Wheat100% + lentils 75%	53.00	130.67	19.83	22.93
T5: Wheat100% + lentils 100%	56.00	94.67	23.38	25.87
LSD (0.05)	5.77	34.40	10.83	7.76

Table 3. Effect of mixed cropping wheat with lentils on lentils yield components

Treatment	Plant height (cm)	Grain yield t ha^{-1}	straw yield t ha^{-1}
T2: Wheat100% + lentils 25%	52.00	0.26	0.30
T3: Wheat100% + lentils 50%	50.00	0.41	0.57
T4: Wheat100% + lentils 75%	47.00	0.42	0.65
T5: Wheat100% + lentils 100%	49.00	0.47	0.64
T6: Sole lentils	46.00	0.67	1.10
LSD (0.05)	14.44	0.44	0.17

Table 4. Effect of mixed cropping wheat with lentils on grain and straw yields of wheat

Treatments	Grain yield t ha^{-1}	Straw yield t ha^{-1}
T1:Sole wheat (100 kg ha^{-1})	1.78	1.52
T2:Wheat (100 kg ha^{-1}) + Lentils (20 kg ha^{-1})	1.63	1.29
T3:Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1})	1.75	1.41
T4:Wheat (100 kg ha^{-1}) + Lentils (60 kg ha^{-1})	1.25	1.09
T5:Wheat (100 kg ha^{-1}) + Lentils (80 kg ha^{-1})	0.98	0.96
LSD (0.05)	0.24	0.23

Table 5. Effect of mixed cropping wheat with lentils on grain and straw yields of lentils

Treatments	Grain yield t ha^{-1}	Straw yield t ha^{-1}
T2:Wheat (100 kg ha^{-1}) + Lentils (20 kg ha^{-1})	0.26	0.30
T3:Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1})	0.41	0.57
T4:Wheat (100 kg ha^{-1}) + Lentils (60 kg ha^{-1})	0.42	0.65
T5:Wheat (100 kg ha^{-1}) + Lentils (80 kg ha^{-1})	0.47	0.64
T6: Sole lentils (80 kg ha^{-1})	0.67	1.10
LSD (0.05)	0.44	0.17

Table 6. Effect of mixed cropping wheat with lentils on Land Equivalent Ratio (LER) of total grain and straw yields of wheat and lentils

Treatments	Total LER of Grain yield	Total LER of Straw yield
T2: Wheat (100 kg ha^{-1}) + Lentils (20 kg ha^{-1})	1.31	1.12
T3: Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1})	1.59	1.45
T4: Wheat (100 kg ha^{-1}) + Lentils (60 kg ha^{-1})	1.33	1.31
T5: Wheat (100 kg ha^{-1}) + Lentils (80 kg ha^{-1})	1.25	1.21
LSD (0.05)	0.79	0.26

Table 7. Effect of mixed cropping wheat with lentils on monetary advantage of grain yield

Treatment	Price in Iraqi Dinar	Price in US $
T1: Sole wheat(100 kg ha^{-1})	1411661.0 b	1212.8 b
T2: Wheat (100 kg ha^{-1}) + Lentils (20 kg ha^{-1})	2184310.0 ab	1876.6 ab
T3: Wheat (100 kg ha^{-1}) + Lentils (40 kg ha^{-1})	2829717.0 a	2431.0 a
T4: Wheat (100 kg ha^{-1}) + Lentils (60 kg ha^{-1})	2468128.0 ab	2120.4 ab
T5: Wheat (100 kg ha^{-1}) + Lentils (80 kg ha^{-1})	2412047.0 a	2072.2 ab
T6: Sole lentils(80 kg ha^{-1})	2690100.0 a	2311.1 a
LSD (0.05)	1.12E6	962.45

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