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The effects of wheat residue, intercropping between wheat and lentil and their interactions on vegetative growth

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Abstract
The burial straw layer wheat promoted physical soil and chemical properties. Intercropping may provide a framework to analyse the complexity of the energy flows among the components of agricultural systems and the cycling of nutrients. The aims were to evaluate the influence of wheat straw at ratios, and in addition to an intercropping system of common wheat *Triticum aestivum* and Lentil *Lens culinaris* Medic. and sole cultivation. A factorial field experiment was designed with RCBD (4X3) and was conducted with four replications. It was to evaluate the influence of wheat straw at ratios of 0, 5, 10 and 15% equivalent to (0.0, 10.550, 18.600 and 28.360 Kg/m) and in addition to an intercropping system of wheat and Lentil. The results showed that, the application of 5% straw caused significant increase in leaf area index (LAI) in wheat, and chlorophyll a and the total chlorophyll in Lentil. Intercropping between the two crops was found to increase the length of awn significantly, and also resulted in a significant decrease in apical internodes plant^{-1}, neck length of the spike of wheat, number of tillers plant^{-1}, and number of leaves plant^{-1}in Lentil. The effects of the application treatment between wheat straw and intercropping was significant increasing in LAI, the length of awn, in the content of chlorophyll a, and total chlorophyll of wheat and also cause a significant decrease in LAI, in the number of branch plant^{-1}, number of leaves plant^{-1}of Lentil.

Keywords: intercropping; lentil; sole cultivation, straw, wheat

1. Introduction
A wheat straw or plant residue addition to soil promotes soil physical and chemical properties, such as a reduction in soil pH, a decrease in particle (Dwene, 2003) [9]. Many Iraqi soils are semi-dry and are lacking in organic matter. This lack of organic matter in the soil, lowers down the numbers of useful micro-organisms in the soil, reduce the ability to retain soil moisture and decreases the availability of the nutrients necessary for the growth and development of the plants leading to a lower yield in the end. Addition, in the field, species diversity is increased by intercropping: like growing two crop species together for a significant portion of their growth cycle (Vandermeer, 1989) [23]. Growing cereals and grains legumes together offers many potential benefits e.g., quantity and quality of yield, improvements to soil biogeochemistry, and pest control (Jeuffroy *et al*., 2015; Raseduzzaman and Jensen, 2017) [15, 19]. Nevertheless, further studies showed that when wheat straw was added and incorporated in the soil and there were significant increases to the total dry weight, yield, number of branch/ plant and, plant height, in a wheat and lentil intercropping (Hassan, 1980; Al -Suliman *et al*., 1987; Swavanka *et al*., 1977; Aase *et al*., 1996) [11, 20, 1]. Unger (1978) found that the wheat straw affected germination and early seedling establishment of sorghum and reduced soil temperature in spring and summer. Although, Mather and Stewart (1974) suggested that high levels of wheat straw reduced seedling growth of corn, Ahmed and Sarmamy (2008) found that the wheat straw has a significant effect on increasing the 1000 seeds weight of wheat and number of pods plant^{-1} of lentil.
Furthermore, Hassan (2004) [11] showed that intercropping systems had a positive effect on the LAI of Maize, plant height, and, number of leaves plant^{-1}of ground nut species compared to the sole system. Akter *et al* (2004) [4] and Islam *et al* (1991) [4] found that LAI, plant height and number of leaves plant^{-1}for wheat and lentil increased as a result of intercropping and used an intercropping system that compares two and three rows. However, Carr *et al*., (2004) [7] and Bonjar-Ghanbari and Lee (2003) [10] reported rise in crude protein%, fibre %, carbohydrate % in an intercropping system for winter wheat, spring wheat and pea. The winter wheat was observed to perform better than spring wheat. Other researchers (Szumigalski and Acker, 2006; Mpairwe *et al*., 2002; Mohammed, 2006) [21, 18, 17] have found that intercropping systems increased the dry weight for wheat, corn, sorghum, canola, pea and legumes compared to the sole system. Thus, the objective of this study was to determine the effects of combining wheat straw layer on soil and intercropping on a wheat + lentil system.

2. Material and Methods
This study was carried out in the fields of the college of Agriculture, University of Salahaddin, Erbil during the years 2005-2006 (36°09 ‘44.73” N; 44°00’49.97” E). The soil texture is silty clay. The main physico-chemical properties of the pre-experiment soil are presented in **Table 1**.
The seeds of wheat (*Triticum aestivum* var. Abo-Xrab 3) and lentil (*Lens culinaris* Medic. var. Barka) were used as plant material. Seeds were obtained from the Ankawa Research Station of Erbil. The wheat straw was used at ratios of 0, 5, 10 and 15% equivalent to (0.0, 10.550, 18.600 and 28.360 Kg /m) and in addition to an intercropping system of common wheat (*T. aestivum* L.) and Lentil (*L. culinaris* Medic.) and along with a sole cultivation. Crops were sown on 12 November 2005.

The experiment was laid in a randomised complete block design (RCBD) with four replicates (4x3). The block contained 12 plots. Each plot was measured 4.5 m² (1.5 x 3 m²), and spaced 0.5 m. In intercrop plots, the two species were mixed within each row.

Nitrogen (Urea 46%) fertilisers were added three times as an amount of 12.5 kg. ha^{-1}. The first-time phosphate ($P_2O_5$46%) was added along with nitrogen to the plant a 2.5 kg. ha^{-1}, the second and third addition of nitrogen were during the branch and flowering stages a 5 kg. ha^{-1}.

Both the crop species growth characteristics were measured such as ;leaf area index, plant height, number of tillers $plant^{-1}$, number of branch $plant^{-1}$, number of leaves $plant^{-1}$, flag leaf length, awn length, neck length of the spike, spike length, chlorophyll a, b and total chlorophyll contents (Al-Barzanj, 2005) [5].

Table 1: The soil properties of the pre-experimental soil in the study site collected at 0–30cm depth.

Physical properties	Value
Particle Size Distribution	
Sand	12.30%
Silt	49.60%
Clay	30.10%
Textural Name	Silty clay
Chemical properties	Value
pH	7.90%
EC e at 25°C	0.44 dS m-1
Organic Matter	0.81%
Available N	0.08%
Available P	0.33%
Available K	20.46 mmol L^{-1}

1 mmhos. cm -1 =1 dS. m-1

Statistical Analysis

Data was subjected to analysis of variance (ANOVA), using SAS and the comparisons of trait' means for both factors and their interactions were made using revised least Significant Difference (R-LSD) range test at 5% level of probability (Scarisbrick and Clewer, 2001) [8].

3. Results and Discussion

The effect of straw wheat on characteristic growth stage of wheat species

The LAI of wheat was significantly different with the effect of wheat straw at 5% comparison with control treatment 7.25 and 3.87%, respectively (Table 2). Regarding the three levels of wheat straw were not significantly different from wheat LAI. In addition, the 5% of wheat straw has been (highest) LAI of wheat specie because, the 5% of straw wheat in the soil is good to grow plant wheat specie (Table 1). Furthermore, it increases organic matter, soil concentration wet, microorganism activate, increase mineral nutrition in soil and to increase activities and growth wheat plant. According to Ahmed and Sarmamy (2008) the wheat straw for the soil to add was increased 1000 seeds weight of wheat specie.

Table 2: The effect of wheat straw on charities growth stage of wheat.

wheat straw (%)	LAI	plant height (cm)	No tillers plant-1	flag leaf length (cm)	awn length (cm)	spike length (cm)	neck length of the spike (cm)	Chlorophyll content a	Chlorophyll content b	Chlorophyll content total
0	3.87	93.3	4.85	22.1	5.59	31.1	16.1	0.36	0.13	0.51
5	7.25*	93.9	4.28	23.1	5.49	32. 3	16.3	0.29	0.12	0.44
10	6.17	96.8	5	22.1	5.46	32.3	17.6	0.3	0.14	0.47
15	6.22	88.4	4.49	22.1	5.63	32.9	17	0.29	0.11	0.43
R.LSD $^{0.05}$	1.88	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS. No Significant; *: Significant at (0.05); R.LSD $_{(0.05)}$: least Significant Difference.

The effect of intercropping on characteristic growth stage of wheat species

The intercropping for the wheat and lentil showed a significant effect of awn length, neck length of the spike, spike length (Table 3). However, the intercropping had not a significant effect on other characteristic in this study. We agree with Hassan (2004) [11] who showed that intercropping between Maize and pea nut and Ahmed and Sarmamy (2008) also showed that the intercropping for wheat and lentil was significant increasing of wheat crop yield. However, the lentil specie is lower in comparison to grow exposed to lower sunshiny, it cannot complete its growth stage and yield.

Table 3: The effect of intercropping on charities growth stage of wheat.

Method of planting	LAI	plant height (cm*)*	No tillers plant-1	flag leaf length (cm)	awn length (cm)	spike length (cm)	neck length of the spike*)* cm)	Chlorophyll content a	Chlorophyll content b	Chlorophyll content total
sole wheat	5.32	92.4	4.45	22.8	5.39	32.9*	17.7*	0.29	0.11	0.43
Inter-crops wheat + lentil	6.44	93.7	4.86	21.8	5.69*	31.3	15.6	0.32	0.13	0.49
R.LSD $^{0.05}$	NS	NS	NS	NS	0.259	1.353	1.279	NS	NS	NS

The effect interaction between the wheat straw and intercropping on characteristic growth stage of wheat species

Data present in Table 4 that wheat straw and intercropping were significantly affected on the LAI, awn length, chlorophyll a, and total chlorophyll contents. Furthermore, three wheat straw levels 5, 10 and 15% with intercropping were obtaining a high LAI from 7.80, 6.88, and 7.48 compares with out -straw 4.15.

No significant difference was observed between three wheat straw levels and intercropping on LAI. The maximum value of LAI wheat specie was found for 5% straw wheat level and intercropping. Although, some other researchers: Hassan (2004) [11] found that intercropping was increasing yield crops between corn and peanut and Ahmed and Sarmamy (2008) showed that intercropping was significantly increasing awn length, percentage of dry gluten of wheat, Land Equivalent Ratio.

Table 4: The effect of wheat straw and intercropping on charities growth stage of wheat.

Method of planting	wheat straw (%)	LAI	plant height (cm)	No tillers plant-1	flag leaf length (cm)	awn length (cm)	spike length (cm)	neck length of the spike (cm)	Chlorophyll content a	Chlorophyll content b	Chlorophyll content total
	0	4.15	95.1	4.75	22.5	5.38	31.8	17.1	0.294	0.125	0.445
Sole wheat	*5*	6.7	91.2	3.85	24.1	5.25	32.4	15.9	0.302	0.121	0.449
	10	5.45	94	4.55	22.5	5.55	33.3*	19.3*	0.287	0.141	0.452
	15	4.96	89.2	4.65	22.2	5.39	34.1*	18.8*	0.287	0.081	0.392
	0	3.59	91.5	4.95	21.8	5.80*	30.3	15	0.416*	0.127	0.578*
Intercrops wheat + lentil	*5*	7.80*	96.5	4.7	22	5.73	32.1	16.7	0.28	0.126	0.433
	10	6.88	99.6	5.45	21.8	5.37	31.2	15.8	0.315	0.139	0.487*
	15	7.48	87.6	4.33	21.9	5.87*	31.8	15.1	0.303	0.145	0.473*
R.LSD $^{0.05}$		*2.665*	NS	NS	NS	*0.518*	*2.71*	*2.56*	*0.103*	NS	0.059

The effect of wheat straw on characteristic growth stage of lentil species

Thanks to the data presented in Table 5, that wheat straw was significantly affected on the LAI, number of tillers plant^{-1}, and number of leaves plant^{-1} of lentil specie. Therefore, intercropping and the 10% level of wheat straw was significant reducing LAI, number of branch plant^{-1}, number of leaves plant^{-1}, whereas it was not significantly affected on another characteristic.

Our results demonstrate that the intercropping systems between the two species; wheat and lentil was positively affecting some characteristic growth stage of wheat specie and negative affected of lentil specie. Overall, the wheat specie had a greater competition than of the lentil specie. In addition, the surface growth root system of wheat specie has a strong effect on nutrient availability than of the lentil specie. Furthermore, wheat specie knows one of the stressful and allelopathy specie.

Table 5: The effect of wheat straw on charities growth stage of lentil.

wheat straw (%)	LAI	plant height (cm)	No tillers plant-1	No leaf length (cm)	Chlorophyll content a	Chlorophyll content b	Chlorophyll content total
0	0.691	38.1	6.57	33.5	0.218	0.069	0.31
5	0.718	38.9	6.72	44.7	0.261*	0.095	**0.38*
10	0.577*	37.5	6.42	36.9	0.243	0.098	0.36
15	0.697	39.7	7.48	43.1	0.232	0.099*	0.34
R.LSD $^{0.05}$	*0.112*	NS	NS	NS	*0.0402*	*0.029*	*0.059*

The effect of intercropping on characteristic growth stage of lentil species

Table 6 showed that negatively intercropping system was significantly affected on the number of tillers plant^{-1}, and number of leaves plant^{-1} of lentil specie whereas it was not significantly affected on other characteristic we worked on.

Table 6: The effect of intercropping on charities growth stage of lentil.

Method of planting	LAI	plant height (cm)	No tillers plant-1	No leaf length (cm)	Chlorophyll content a	Chlorophyll content b	Chlorophyll content total
sole lentil	0.69	38.2	7.93*	49.0*	0.233	0.09	0.34
intercrops wheat + lentil	0.66	9.38	68.5	30.1	0.245	0.08	0.36
R.LSD $^{0.05}$	NS	NS	1.61	9.87	NS	NS	NS

The effect intercropping between wheat straw and intercropping on characteristic growth stage of lentil species

Table 7 showed that wheat straw and intercropping were significantly affected on the LAI, number of tillers plant^{-1}, and number of leaves plant^{-1} of lentil specie. We can note that interaction while both intercropping system and 10% of wheat straw level, were significantly reduced the LAI, number of tillers plant^{-1}, and number of leaves plant^{-1} of lentil. However, it was not significantly affecting another characteristic of this study.

Table 7: The effect of wheat straw and intercropping on charities growth stage of lentil.

Method of planting	wheat straw (%)	LAI	plant height (cm)	No tillers plant-1	No leaf length (cm)	Chlorophyll content a	Chlorophyll content b	Chlorophyll content total
	0	0.705	36.95	7.45	40.05	0.216	0.069	0.31
sole lentil	*5*	0.708	36.91	7.05	52	0.256	0.092	0.37
	10	0.613	38.02	8.1	49.25	0.246	0.102	0.371
	15	0.718	41.05	9.10*	54.75*	0.212	0.099	0.311
	0	0.677	39.31	5.7	27	0.221	0.096	0.31
intercrops wheat + lentil	5	0.728	40.91	6.4	37.3	0.267	0.098	0.388
	10	0.541*	37.03	4.75	24.55	0.239	0.093	0.353
	15	0.676	38.33	5.87	31.53	0.253	0.1	0.374
R.LSD $^{0.05}$		0.161	NS	3.213	19.74	NS	NS	NS

4. Conclusion

Our examination demonstrates that the intercropping systems between the two species; wheat and lentil was positively affecting some growth stage characteristics of wheat specie and negatively affecting the lentil specie. Overall, the wheat specie had a greater competition than the lentil specie. In addition, the surface growth root system of wheat specie has a strong effect on the nutrient availability than of lentil specie. Furthermore, wheat specie is one of the most stressful and allelopathy specie.

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Author Contributions Statement

LQA and AGOIS designed the research. LQA conducted the experiment and analysed the data. LQA wrote the manuscript with contribution from AGOIS. Both authors approved the final version of manuscript.

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Compliance with ethical standard

Conflicts of Interest: The authors declare that they have no conflict of interest.

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