The Role of Intercropping Wheat with Legumes (Chickpea or Pea) in Improving the yield and Land Equivalent Ratio in Rain fed Regions

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Abstract:

This study was conducted to estimate the response of some characters of such as biological yield, grain yield, harvest index and Land equivalent ratio. chlorophyll and protein content of Araz bread which, **intercropped with two legume crops, chickpea and pea with some different patterns namely [sole wheat, sole wheat + fertilizer, 1 wheat: 1 legume (chickpea or pea) , 2 wheat: 1 legume (chickpea or pea), 1 wheat: 2 legumes(chickpea or pea) and broadcast treatments]. This experiment was conducted at two different locations Qlyasan and Kanipanka during the winter season 2008 – 2009, and was designed according to Split Plot Design within factorial experiment with three replications. As the average of both locations, the response of wheat characters to both legume crops was significant for biological yield, grain yield and harvest index. Chickpea had more effect on wheat characters than pea in biological yield, grain yield, and harvest index. The intercropping systems significantly affected the wheat characters, biological yield, grain yield, harvest index, LER, flag leaf area, chlorophyll and protein content. It was found that the cropping system of 1wheat: 2 legumes (pea , chickpea) were more effective on most important wheat characters compared to other systems, whereas the systems of sole wheat and broadcast exhibited the lowest effect on most characters. The effect of locations was significant on most important characters and the Qlyasan location was superior in grain yield only.**

Key words: bread wheat, chickpea and pea, intercropping system, Land Equivalent Ratio

I. Introduction:

Grain legumes (pulses) such as field pea and chickpea are rich in protein and suited for animal feed as well as for human diet. Other positive effects of pea are the symbiotic nitrogen fixation ability supplying N for agriculture, recycling of N-rich crop residues and the break-crop effect in cereal rich rotations [1]. Producers and researchers carry out different cropping systems to increase productivity and sustainability by practicing crop rotations, relay cropping, and intercropping of annual cereals with legumes [2].Intercropping is one of the important ways of increasing crop production per unit area as well as income, both under rainfed and irrigated conditions. Such practice aims to ensure, against total crop

failure in uncertain weather condition, increasing of total productivity, equitable and judicial use of land resources and farming inputs including labour [3]. It is a unique system in developing countries particularly practiced by small farmers to increase diversity of their farm products [4]. However, growing population and country's need to increase agricultural production from steadily decreasing and degrading land resources has led the agriculturists to emphasize intercropping primarily to maximize crop production and profits by maintaining a full population of component crops. Development of a feasible and economically viable intercropping system depends largely on selection of compatible crops and adoption of proper planting geometry [5]. The cereal intercrop systems provided no consistent yield benefit over wheat monocultures. Results from noncereal-wheat intercrops were variable. Wheat-field pea resulted in the lowest disease levels, yet had inconsistent yields, and more weeds than wheat monoculture [6]. The main objectives of the present study were

(i) to estimate the effect of competition within cereal-legume intercropping systems, e.g., wheat chickpea and wheat-pea intercropping; (ii) to examine different competition indices in these intercropping systems and, therefore (iii) to evaluate the systems for better management of resources to obtain less competition among plants, higher productivity, sustainability, and economic value.

II. Material and methods:

This study was conducted at two different locations Qlyasan research station (35˚ 34′ 307″ N; 45˚ 21′ 992″ E; and 755 m. a. s. l. (meter above soil level), located 2km north west of Sulaimani and Kanipanka location (35˚22′ 37″ N; 45˚43′33″ E; 545 m. a. s. l. in Sharazoor plain zone 35 km east of Sulaimani, during the winter season (2008-2009) to investigate the organic performance of bread wheat *Triticum aestivum* var. Araz (Sonara 64 x Lerma Roja 64) x Sentaelena, originated in Mexico, as intercropped with two legume crops (chickpea and pea)under different intercropping systems . The experiment was laid out according to Split Plot Design, replicated three times, the legume crops (chickpea or pea) were distributed in the main plots that were arranged as (RCBD), while the intercropping systems were placed in the subplots. Legume crops were sown in alternative rows with wheat. Each sub plot consists of 5 rows of 3 m long, and planting patterns comprised of 0.25 m, space between replications and also main plots were 1.0 m apart. The land of experiment was prepared by plowing the field twice using Mold broad plow and harrowed using disk harrow. Drilling was conducted at 12 and 17 November for both locations Qlyasan and Kanipanka respectively, using the recommended seed rates of 200 kg/ha for wheat and 120 kg / ha for both chickpea and pea. The experiment was fertilized with phosphorus applied as broadcast method at a recommended rate of 80 kg P2O5 /ha, the rate of 80 kg N /ha was also applied for the treatment sole wheat + fertilizer only. All cultural practices were conducted wherever necessary. The main plots were comprised two legume crops chickpea (*Cicer aritinum*) and pea (*Pisum sativum*). The sub plots were comprised of intercropping patterns [sole wheat, sole wheat +fertilizer, 1 wheat + 1 legume (chickpea or pea**)**, 2 wheat + 1 legume (chickpea or pea), 1 wheat + 2 legume (chickpea or pea) and broadcast wheat + legume]. At full maturity all plots harvested excluding

guard row on 31 and 30 May for both locations Qlyasan and Kanipanka respectively. Traits evaluated:

- Wheat yield traits: Biological yield (t/ha), Grain yield (t/ha).[7], Harvest index.
- Land Equivalent Ratio (LER): [8], LER = $(Y_{ab} / Y_{aa}) + (Y_{ba} / Y_{bb})$ Where: Y_{aa} and Y_{bb} are the sole crop yields of wheat and different forage legumes respectively. Y_{ab} is the intercrop yield of wheat, and Y_{ba} is the intercrop yield of forage legumes.
- Flag leaf area: Leaf area = leaf length × leaf widest part × 0.74 [9]
- Chlorophyll content [10]:

A= absorbance: µg chlo.a/ml solution = (13.7) (A665nm) - (5.76) (A649nm).

A= absorbance: µg chlo.b/ ml solution = (25.8) (A649nm) - (7.6) (A665nm).

Total chlorophyll = chlo.a + chlo.b

Grain protein content: % protein calculated as follow: % protein = grain N% × 5.7 [11].

II. Results and discussion:

Data in (Table I) indicates the effect of legume crops on the average values of wheat traits as biological yield, grain yield, harvest index and LER for grain yield at both locations and their averages .In the first location only grain yield trait responded significantly to the effect of legume crops. Generally the effect of chickpea was greater than that of pea in these traits with the exception of LER. The effect of chickpea outyielded pea in the first location by 8.63, 9.15 and 1.83 % for the traits biological yield, grain yield and harvest index respectively, while for the trait of LER pea predominated chickpea by 18.78 %. Data in the same table confirm that none of the legume crops had significant effects on these traits in the second location. Regarding the average of both locations as presented in the same table, it was found that the legume crops significantly affected all traits with exception of LER. Chickpea out yielded pea by 5.91 %, 7.69 % and 7.08 % for biological yield, grain yield and harvest index respectively. Generally it was noticed that chickpea had more effect comparing to pea in most traits, this may be due to it's ability in nitrogen fixation and good association with wheat in compare to pea. Data in (Table II) show the effect of legume crops on wheat flag leaf area, chlorophylls content and wheat grain protein content. In the first location the effect was found to be significant on protein content only. Generally the effects of pea on the traits wheat flag leaf area, chlorophyll content and wheat grain protein content were greater than the effect of chickpea by 5.49, 7.03 and 12.61 % respectively.

Table.I: Effect of legume crops on wheat biological and grain yield, harvest index and land equivalent ratio (LER) for both locations with their average

Legume crops	Biological yield (t/ha)	Grain yield (t/ha)	Harvest index	LER for grain Yield
Qlyasan location				
Chickpea	15.135	4.108	0.272	0.995
Pea	13.829	3.732	0.267	1.225
$LSD_{(0.05)}$	N.S	0.245	N.S	N.S
Kanipanka location				
Ch**ickpea**	8.799	3.147	0.377	0.987
Pea	8.691	2.966	0.336	1.095
$LSD_{(0.05)}$	N.S	N.S	N.S	N.S
Average of locations				
Chickpea	11.9 67	3.628	0.325	0.991
Pea	11.260	3.349	0.302	1.160
$LSD_{(0.05)}$	0.475	0.123	0.018	N.S

Table.II: Effect of legume crops on wheat flag leaf area chlorophyll and protein content for both locations with their average.

Legume crops	Flag leaf area (cm^2)	Chlorophyll content (mg/g)	protein %
Qlyasan location			
Chickpea	42.820	1.747	11.069
Pea	45.310	1.879	12.666
$LSD_{(0.05)}$	N.S	N.S	1.110
Kanipanka location			
Chickpea	30.879	0.938	10.752
Pea	31.245	0.962	10.004
$LSD_{(0.05)}$	N.S	N.S	N.S
Average of both locations			
Chickpea	36.850	1.343	10.911
Pea	38.278	1.421	11.335
$LSD_{(0.05)}$	N.S	N.S	N.S

Data in (Table III) and explain the effect of associating of wheat with legume crops on wheat biological yield, grain yield, harvest index and LER for wheat crop for both locations with their average. In both locations the intercropping systems exhibited significant effect on all traits with the exception of harvest index. The intercropping system 1:2 exhibited maximum value for all traits in both locations with their average which were 17.01 t/ha, 4.862 t/ha, 0.286 and 2.138 for wheat biological yield, grain yield, harvest index and LER in the first location respectively, while in the second location they were 10.76 t/ha, 3.995 t/ha, 0.372 and 2.08 respectively and for the average of both locations were 13.885 t/ha, 4.429 t/ha, 0.329 and 2.109 respectively. Several previously researchers [12, 13 and 14] noticed that intercropping of legumes and cereals had produced higher yields in comparison to sole cereal crops without nitrogen fertilization. Previous results indicated that intercropping of legumes and cereals were found to improve the utilization of plant growth resources i.e. LER>1 as compared to the sole crops [15 and 16]. However, other researchers indicated that in most intercropping experiments, the yield of a given crop in the mixture is less than the yield of the same crop grown a lone, but the total productivity per unit of land is usually greater for the mixtures than for the sole crops. Intercropping greatly increased the total production as compared to the sole stands with a simple exception of an intercropping system, when reduction occurred in cereal grain yield grown at the same row [17, 18 and, 19]. The effect of intercropping systems on flag leaf area, chlorophyll and protein content were reported in (Table IV) which was found to be significant in the traits flag leaf area and protein content in both locations with their average. Maximum flag leaf area in the first location was 47.715 cm^2 exhibited by the system sole wheat + fertilizer, while in the second location and the average of both locations were 37.087 and 40.163 cm^2 respectively showed by the system 1:2. Data in the same table explain the effect of intercropping system on chlorophyll content. Maximum chlorophyll content values of 2.022 and 1.496 mg/g in the first location with the average of both locations were respectively, which exhibited by the intercropping system 1:1,while in the second location the maximum value of chlorophyll content was 0.995 mg/g showed by sole wheat + fertilizer. Previous workers reported that the crude protein concentration of intercropping cereals was increased compared to sole crop [11, 20 and 21].

Table.III: Effect of intercropping systems on wheat biological and grain yield, harvest index and land equivalent ratio (LER) for both locations with their average.

Intercropping systems	Biological yield (t/ha)	Grain yield (t/ha)	harvest index	LER for grain yield
Qlyasan location				
Sole wheat	12.843	3.270	0.251	----
Sole wheat + fertilizer	14.343	3.817	0.266	
System (1 : 1)	16.427	4.602	0.280	1..827
System (2 : 1)	13.510	3.552	0.265	1.465
System (1 : 2	17.010	4.862	0.286	2.138
Broadcast	12.751	3.420	0.266	1.230
LSD $_{(0.05)}$	0.477	0.408	N.S	0.199
Kanipanka location				
Sole wheat	7.718	2.483	0.338	----
Sole wheat +	8.177	2.755	0.353	----
System (1 : 1)	10.093	3.665	0.363	1.720
System (2 : 1)	8.760	3.118	0.367	1.404
System (1 : 2)	10.760	3.995	0.372	2.080
Broadcast	6.962	2.337	0.345	1.040
LSD $_{(0.05)}$	0.466	0.264	N.S	0.296
Average of both locations				
Sole wheat	10.281	2.877	0.295	----
Sole wheat	11.260	3.286	0.310	----
System (1 : 1)	13.260	4.134	0.322	1.774
System (2 : 1)	11.135	3.335	0.316	1.435
System (1 : 2)	13.885	4.429	0.329	2.109
Broadcast	9.857	2.879	0.306	1.135
LSD $_{(0.05)}$	0.323	0.236	0.019	0.169

Data in (Table V) showed to the presence significant interaction between legume crops and intercropping systems for the characters wheat biological yield, grain yield, harvest index and LER in the first location. It was observed that the association between pea and the system 1:2 produced maximum values of 17.26 t/ha, 5.103 t/ha, 0.296 and 2.513 for biological yield, grain yield, harvest index and LER respectively. The effect of interaction between legume crops and intercropping systems in the second location were significant for all characters with the exception of grain yield maximum biological yield as produced by the interaction between chickpea and the system 1:2 was 11.26 t/ ha, while the maximum grain yield and LER exhibited by the interaction between pea and the system 1:2 which were 4.587 t/ha and 2.378 respectively, but maximum harvest index was 0.41 exhibited by the interaction between chickpea and system 2:1. Data in

the average of both locations confirmed the presence of significant interaction between legume crops and intercropping system for the characters biological yield, grain yield, harvest index and LER. The interaction between chickpea and system 1:2 showed maximum biological yield which was 14.01 t/ha, while maximum values of 4.587 t/ha, 0.345 and 2.378 for grain yield, harvest index and LER respectively. The interaction effect between legume crops and intercropping system on wheat flag leaf area, chlorophyll content and protein content were explained in (Table VI)for both locations and their average. This effect was only significant on chlorophyll and protein contents in the first location. Maximum flag leaf area was 49.404 cm^2 exhibited by the combination between chickpea and sole wheat + fertilizer. Maximum chlorophyll content was 2.236 mg/g showed by the association between chickpea and the system 1:1. Regarding the protein content as reported in the same table, the maximum value for this trait was 13.740 % produced by the combination of pea and broad cast. Table in the second location show the presence of significant interaction between legume crops and the intercropping systems on the above traits, the association of pea and system 1:2 predominated all in flag leaf area which was 37.583 cm^2. The same table shows effect of the interaction between pea and sole wheat+ fertilizer on chlorophyll content, which gave highest chlorophyll content of 1.09 mg/g. Concerning protein content, the interaction between chickpea and sole wheat +fertilizer gave the highest value of 11.54 % for this trait. The average of both locations showed the significant interaction effect for all traits. The interaction between chickpea and sole wheat +fertilizer produced maximum flag leaf area 40.799 cm^2 .The combination between pea and broadcast system showed maximum values of 2.911 mg/g and 11.86 % for both chlorophyll and protein content respectively. Data in (Table VII) explain the effect of locations on wheat biological yield, grain yield, harvest index and LER. It was noticed that this effect was significant for only grain and biological yield. Qulyasan location significantly predominated Kanipanka location in the traits, biological and grain yield by 39.61% and 22.02 % respectively, but for LER was not-significant. The predominance of Qulyasan location in these traits may be due to the precipitation amount and it's distribution which was found to be more suitable in Qulyasan location than in Kanipanka.

Table.IV: Effect of intercropping systems on flag leaf area, chlorophyll and protein content of wheat for both locations with their average.

Intercropping systems	Flag leaf area (cm^2)	Chlorophyll content (mg/g)	Protein %
Qlyasan location			
Sole wheat	41.703	1.898	11.385
Sole wheat + fertilizer	47.715	1.892	12.005
System (1 : 1)	43.058	2.022	11.373
System (2 : 1)	41.780	1.494	11.200
System (1 : 2)	43.239	1.796	12.375
Broadcast	46.892	1.803	12.868
LSD $_{(0.05)}$	3.513	N.S	0.756
Kanipanka location			
Sole wheat	30.501	0.925	9.610
Sole wheat + fertilizer	29.362	0.995	10.840
System (1 : 1)	29.249	0.970	10.340
System (2 : 1)	30.872	0.936	10.655
System (1 : 2)	37.087	0.960	10.445
Broadcast	29.303	0.915	10.385
LSD $_{(0.05)}$	2.058	N.S	0.496
Average of both locations			
Sole wheat	36.102	1.412	10.498
Sole wheat + fertilizer	38.539	1.444	11.423
System (1 : 1)	36.154	1.496	10.857
System (2 : 1)	36.326	1.215	10.928
System (1 : 2)	40.163	1.365	11.410
Broadcast	38.098	1.359	11.627
LSD $_{(0.05)}$	2.204	0.164	0.438

Table.V: Effect of interactions between legume crops and intercropping systems on wheat biological yield, grain yield, harvest index and land equivalent ratio (LER) for both locations with their average.

Intercropping systems / legume Crops		Biological yield (t/ha)	Grain yield (t/ha)	Harvest index	LER for grain yield	Biological yield (t/ha)	Grain yield (t/ha)	Harvest index	LER for grain yield	Biological yield (t/ha)	Grain yield (t/ha)	Harvest Index	LER for grain yield
		Qlyasan location				Kani Panka Location				Average of Both Location			
Chickpea	Sole wheat	13.093	3.790	0.286	----	7.260	2.516	0.376	----	10.177	3.153	0.331	---
	Sole wheat + fertilizer	14.926	3.967	0.266	----	8.093	2.810	0.376	---	11.510	3.389	0.321	---
	System (1 : 1)	17.093	4.773	0.280	1.627	9.926	3.783	0.380	1.603	13.510	4.278	0.330	1.615
	System (2 : 1)	15.510	3.793	0.243	1.452	8.926	3.400	0.410	1.281	12.218	3.597	0.327	1.367
	System (1 : 2)	16.760	4.620	0.276	1.763	11.260	3.920	0.350	1.916	14.010	4.270	0.313	1.840
	Broadcast	13.426	3.707	0.276	1.126	7.330	2.483	0.366	1.120	10.378	3.095	0.321	1.123
Pea	Sole Wheat	12.593	2.750	0.216	----	8.176	2.450	0.300	---	10.385	2.600	0.258	---
	Sole wheat + fertilizer	13.760	3.667	0.266	----	8.260	2.700	0.330	---	11.010	3.184	0.298	---
	System (1 : 1)	15.760	4.430	0.280	2.026	10.260	3.546	0.346	1.837	13.010	3.988	0.313	1.932
	System (2 : 1)	11.510	3.310	0.286	1.478	8.593	2.836	0.323	1.527	10.052	3.073	0.305	1.503
	System (1 : 2)	17.260	5.103	0.296	2.513	10.260	4.070	0.393	2.243	13.760	4.587	0.345	2.378
	Broadcast	12.076	3.133	0.256	1.333	6.593	2.190	0.323	0.959	9.335	2.662	0.290	1.146
	$LSD_{(0.05)}$	0.675	0.578	0.038	0.281	0.660	N.S	0.042	2.175	0.457	0.333	0.027	0.239

Table.VI: Effect of interaction between legume crops and intercropping systems on wheat flag leaf area, protein content for both locations with their average:

Legume crops	Intercropping systems	Flag leaf area (cm^2)	Chlorophyll content (mg/g)	Protein %	Flag leaf area (cm^2)	Chlorophyll content (mg/g)	Protein %	Flag leaf area (cm^2)	Chlorophyll content (mg/g)	Protein %
			Qlyasan location			Kani Panka Location			Average of Both Location	
Chickpea	Sole wheat	39.268	1.583	9.833	30.306	0.980	9.280	34.787	1.282	9.557
	Sole wheat + fertilizer	49.404	1.933	11.250	32.194	0.900	11.540	40.799	1.417	11.395
	System (1 : 1)	39.622	2.236	10.526	27.963	0.930	11.130	33.792	1.583	10.828
	System (2 : 1)	39.619	1.267	11.140	30.947	0.902	10.990	35.284	1.085	11.065
	System (1 : 2)	43.488	1.506	11.670	36.5092	0.950	10.790	40.397	1.228	11.230
	Broadcast	45.515	1.955	11.996	27.273	0.960	10.790	36.394	1.458	11.393
Pea	Sole Wheat	44.138	2.212	11.936	30.696	0.870	9.940	37.417	1.541	11.438
	Sole wheat + fertilizer	46.026	1.851	12.760	26.530	1.090	10.140	36.278	1.471	11.450
	System (1 : 1)	46.494	1.807	12.220	30.535	1.010	9.550	38.515	1.409	10.885
	System (2 : 1)	43.941	1.720	11.260	30.797	0.970	10.320	37.369	1.345	10.790
	System (1 : 2)	42.989	2.031	11.080	37.583	0.970	10.100	40.286	1.501	11.590
	Broadcast	48.268	1.650	13.740	31.333	0.870	9.980	39.800	2.911	11.860
	$LSD_{(0.05)}$	N.S	0.471	1.069	4.058	0.086	0.702	3.117	1.733	0.619

Table.VII: Effect of locations on wheat biological yield, grain yield, harvest index and land equivalent ratio (LER).

Locations	Biological yield (t/ha)	Grain yield (t/ha)	Harvest index	LER for grain Yield
Qlyasan	14.482	3.920	0.270	1.110
Kanipanka	8.745	3.057	0.357	1.041
$LSD_{(0.05)}$	1.366	0.745	N.S	N.S

(Table VIII) demonstrate the presence of significant effect of location on the traits wheat flag leaf area, chlorophyll and protein contents. It was observed that Qlyasan location exceeded Kanipanka location in these traits by 39.51, 47.6 and 12.55 % respectively. Over all it can concluded that Qlyasan location gave better values for almost all studied traits, this may be due to the suitability of this location to produce these crops as result of better environmental condition as precipitation amount and it's distribution and also the presence of better temperature during wheat anthesis and grain filling stages .

Table.VIII: Effect of locations on wheat flag leaf area, chlorophyll and protein content.

Locations	Flag leaf area (cm^2)	Chlorophyll content (mg/g)	Protein %
Qlyasan	44.065	1.813	11.868
Kanipanka	31.062	0.950	10.378
$LSD_{(0.05)}$	11.240	0.674	0.245

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