FORAGE YEILD AND COMPITITION INDICES OF CEREALS MIXED INTERCROPPING WITH FORAGE LEGUMES IN SULAIMANI REGION

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ABSTRACT

The present study was conducted in Sulaimani region at two different locations, Kanipanka and Qlyasan during winter season of 2019-2020 to estimate the response of forage yield and some competition indices to the effect of crop pure stands and their mixtures of barley and triticale intercropped with narbon vetch and grass pea with some different patterns. The experiment was designed according to Completely Randomized Block Design with three replications. As the average of both location the maximum green forage yield was produced by pure narbon vetch 32.610 ton ha^{-1}, while pure barley produce maximum dry forage yield and dry matter % reached 5.506 ton ha^{-1} and 8.55% at booting stage respectively, but the crop mixture barley/grass pea at a rate 2:1 produce maximum green and dry forage yield 32.083 and 5.616 ton ha^{-1} respectively at booting stage. The crop mixture barley/vetch 1:1 gave maximum dry matter% 17.88% at the same stage. The highest value for total LER was 1.401recorded by the mixture of triticale/grass pea at elongation stage, while the highest relative crowding coefficient was 1.285 recorded by the same mixture at a rate 1:1 at the same cutting stage. Maximum competitive ratio for cereals was 3.652 recorded by barley in the mixture barley/grass pea 1:2 at elongation stage, while for legume it was 2.292 for narbon vetch in the mixture triticale/vetch 2:1 at booting stage.

Key word: barley, triticale, crop mixtures, forage legumes

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حاصل العلف ومؤشرات المنافسة لزراعة الحبوب متداخلا مع البقوليات العلفية في منطقة السليمانية

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المستخلص

اجريت هذه الدراسة في موقعين مختلفين في السليمانية وهما كاني بانكة وقلياسان خلال الموسم الشتوي 2019– 2020 لتقييم استجابة حاصل العلف وبعض مؤشرات المنافسة لتأثير زراعة المحاصيل بشكل فردي ومخاليطها الشعير والتريتيكال متداخلا مع الكاكوز والهرطمان حسب بعض نظم التداخل صممت التجربة وفقا لتصميم القطاعات العشوائية الكاملة وبثلاث تكرارات. كمتوسط للموقعين, انتج الكاكوز المزروع بشكل فردي اعلى حاصل للعلف الاخضر 32.610 طن/هكتار, بينما انتج الشعير الفردي اعلى حاصل لعلف الجاف والنسبة المئوية للمادة الجافة 5.506 طن/هكتار و8.55% بالتتابع. انتج الخليط 2شعير/1هرطمان 1:2 اعلى حاصل للعلف الاخضر والجاف وصلت الى 32.083 و5.616 طن/هكتار على التوالي. في مرحلة الحملان سجل حاصل الخليط شعير/كاكوز 1:1 اعلى نسبة للمادة الجافة وصلت 17.88% وفي نفس المرحلة اعلى قيمة لنسبة مكافئ الارض LER وصلت الى 8.403 من خليط ترتيكال/هرطمان خلال مرحلة الاستطالة.

الكلمات المفتاحية: شعير, تريتيكالي, مخاليط علفية وبقوليات علفية.

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INTRODUCTION

The global human population is projected to reach beyond 9.8 billion by the end of the year 2050 (32). Thus, productivity must be increased through sustainable production by taking into account climate change, rarefaction of resources like phosphorus and water, and losses of fertile lands. Crop production should be increased further without deteriorating the soil fertility, environment, and food quality (6, 22). Increasing world population and the urgent need of food products are of the basic problems of today's world. Yet most challenging problem in today's world is food security of human as a first need (4). In recent years, there has been increased interest in agricultural production systems in order to achieve high productivity and promote sustainability over time. Several factors can affect growth of the species used in inter-cropping, including cultivar selection, seeding ratios, and competition between mixture components (8). Such as crop rotation, relay cropping and intercropping of annual cereals with legumes. Intercropping of cereals with legumes has been a common cropping system in rain-fed areas, especially in the Mediterranean countries; (17). Legumes and cereals do not provide satisfactory yields when they are pure seeded. There are some rational reasons of this situation. First of all, legume crops are low-yielding, especially in areas where rainfall is insufficient, and the plant lodging causes some problems during harvest. On the other hand, cereals produce high forage yields but with low protein content which is far from the requirements of many livestock (26). Barley and wheat respectively, are the most suitable cereals for mixtures(27). Different seeding ratios or planting patterns for cereal-legume intercropping have been practiced by many researchers (4,11,37). The greater benefit for forage quality was found when common vetch was grown in a monoculture or in mixture with cereals reported by (17). The objectives of the present study were to evaluate cereals and legumes intercrops compared to mono-crops with regard to the forage production, to estimate the effect of competition within cereals - legumes intercropping systems, and to examine different competition indices in these intercropping systems.

MATERIALS AND METHODS

Site and The Experimental Set Up

Two locations were selected for applying this research in the governorate of Sulaimani which is located in the northeast of Iraq, on the border with Iran., the first was Kanipanka agricultural research station, located at (Latitude: 35^0 22' 22" N, longitude: 45^0 43' 22" E; and altitude of 548 masl), in Sharazoor intermountain 34 km east of Sulaimani, The second was Qlyasan, the research station of Biotechnology and Crop Science Department, Collage of Agricultural Engineering Sciences, University of Sulaimani, located at (Latitude: 35^0 34' 17" N, longitude: 45^0 22' 00" E; and altitude of 757 masl), 2 km northwest of Sulaimani city.

Climatic conditions of Sulaimani region

The climate of Sulaimani governorate is considered as a semi-arid environment: cold and wet in winter, hot and dry in summer. The average temperature from July to august is between 39- 43^0C and often reaching nearly 50^0C. October means high temperatures 24 - 29^0C and slightly cooling down in November. The rainfall is limited to winter and spring months (19).

Plant material and treatments

The seed-bed was well prepared through two perpendicular plowing and removing residual of the previous crop and weeds. Prior to planting, seeds were treated with benomyl at 0.2% [wt/wt] in order to protect them from soil-borne pathogens. Barley and triticale as sole, two legume monocrops, narbon vetch and grass pea as well as mixtures of each of barley and triticale with each of the above two legumes in three seeding ratios (i.e. 1:1, 1:2 and 2:1) based on seed rate.200 kg ha^{-1} for both triticale and Barley and 160 kg ha^{-1} for narbon vetch and grass pea as monoculture, while for cropping-inter 1:1 it was 100:80 kg ha-1and for cropping-inter 1C:2 L it was 66.7:106.7 kg ha-1, but for cropping-inter 2C:1L it was 133.3:53.3 kg ha-1. The seeds were sown in the 12th November in Qlyasan location and 15th November in Kanipanka location 2019. Seeds in mixture treatments were mixed and sown together. The experimental design comprised a randomized

complete block (RCBD) with sixteen treatments. The experimental plots were 3 X 1.5 m (6 rows, 0.25m apart), sixteen treatments were applied: pure triticale (PT), pure barley (PB), pure narbon vetch vetch (PN), pure grasspea (PG), triticale + narbon vetch (TN), triticale + grasspea (TG) barley + narbon vetch (BN) and barley grasspea (BG), 1 triticale +2narbon vetch (1T2N), 1triticale +2grasspea (1T2G),1 barley+2 narbon vetch (1B2N) and 1barley + 2grasspea (1B2G), 2 triticale +1narbon vetch (2T1N), 2triticale + 1grasspea (2T1G), 2barley+1narbon vetch (2B1N) and 2barley +1grasspea (2B1G), Pure stands and mixtures were harvested at two growth harvested at two growth stages of cereals (stem elongation and booting) according to (38). At each stage, four rows of each plot were cut to ground level with manual shears, and the forage in mixture treatments was separated by hand for the determination of the cereals' and legumes' percentage in each mixture. The samples were dried in the oven at 70˚C to a constant weight to determine the dry matter yield. The growth rate of the species between the two cutting dates was calculated. The following competition indices:

Land equivalent ratio

LER indicates the efficiency of cropping-inter, using the environmental resources compared to monocropping (21). When LER >1 the cropping-inter favors the growth and yield of the species. In contrast, when LER < 1 there is no cropping-inter advantage and the -inter specific competition is stronger than the -inter specific interaction within cropping-inter system (39). LER was calculated as:

$LER = (LER_{cereal} + LER_{legume})$;

$LER_{cereal} = Yci / Yc$; $LER_{legume} = Yli / Yl$,

Where Yc is the yield of cereal as sole crops, Yl is the yield of legume as sole crops, Yci is the yield of cereal as crops-inter and Yli is the yield of legume as .crops-inter

Aggressivity

Aggressivity (A) is a competitive index, which is a measure of how much the relative yield of one crop component is greater than that of another (20). Aggressivity is expressed as:

$A_{cereal} = Yci / Yc \times Pci - Yli / Yl \times Pli$

$A_{legume} = Yli / Yl \times Pli - Yci\ Yc \times Pci$,

Where Pci is the sown proportion of cereal in mixture with legume and Pli is the sown proportion of legume in mixture.

If A_{cereal} or $A_{legume} = 0$, both crops are equally competitive. When A_{cereal} is positive then the cereal species is dominant and when it is negative then legume is the dominating species.

Relative crowding coefficient

The relative crowding coefficient (RCC or K) in plant competition theory introduced by (10). The K allowed evaluating and comparing the competitive ability of one species to the other in a mixture (39). The K was calculated as:

$K = K_{cereal} \times K_{legume}$;

$K_{cereal} = Yci \times Pli / (Yc - Yci) \times Pci$;

$K_{legume} = Yli \times Pci / (Yl - Yli) \times Pci$,

If K_{cereal} is greater than K_{legume}, cereal is more competitive than legume. Also, when the product of the two coefficients (K_{cereal} and K_{legume}) is greater than 1 there is a yield advantage, when K is equal to 1 there is no yield advantage, and when it is less than 1 there is a disadvantage.

Competitive ratio

The CR, introduced by (36), was used as an indicator to evaluate the competitive ability of different species in inter-cropping, using the following formula (35, 31).

$CR_{cereal} = LER_c / LER_l \times Pl_i / Pc_i$;

$CR_{legume} = LER_l / LER_c \times Pc_i / Pl_i$,

If $CR_{cereal} > 1$, cereal is more competitive than legume, and if $CR_{cereal} < 1$, then cereal is less competitive than legume (39).

Actual yield loss

The AYL is the proportionate yield loss or gain of inter-crops in comparison to the respective sole crop. In addition, partial AYL_{cereal} and AYL_{legume} represent the proportionate yield loss or gain of each species in intercropping compared to their yield in sole crops. The positive or negative values of AYL indicate the advantage or disadvantage of the inter-cropping (11) The AYL is calculated using the following formula (3):

$AYL_{cereal} = [(Yci / Pci) \ |(Yc / Pc)] - 1$;

$AYL_{legume} = [(Yli / Pli) \ |(Yl / Pl)] - 1$,

$AYL = AYL_{cereal} + AYL_{legume}$.

RESULTS AND DISCSSION

Results in Table 1 show the effect of crop pure stand and their mixtures on green, dry yield ton ha^{-1} and dry matter% at both locations and

their average at elongation stage. There were highly significant differences among treatments for all traits. maximum green and dry yield value for pure stands recorded by narbon vetch reached 37.067 and 4.136 ton ha^{-1} respectively at the first location, but the highest percentage of dry matter was 17.31 % obtained from barley at the second location. The greatest green and dry yield for crop mixtures obtained from barley/vetch 1:2 reached 26.090 and 3.810 ton ha^{-1} respectively at the first location, but the highest dry matter % for mixtures reached 20.30 % obtained from the crop mixture barley/grass pea 2:1 at the second location.

Table1. Effect of Crop pure stand and their mixtures on green, dry yield (ton ha^{-1}) and dry matter (%) at elongation stage at both locations and their average.

Crop mixture	Kanipanka location			Qlyasan location			Average of both locations		
	Green yield ton ha^{-1}	Dry yield ton ha^{-1}	DM %	Green yield ton ha^{-1}	Dry yield ton ha^{-1}	DM %	Green yield ton ha^{-1}	Dry yield ton ha^{-1}	DM %
B	**19.730**	**3.212**	**16.287**	**7.067**	**1.222**	**17.307**	**13.398**	**2.217**	**16.797**
T	**14.577**	**2.293**	**15.760**	**5.503**	**0.758**	**13.803**	**10.040**	**1.526**	**14.782**
V	**37.067**	**4.136**	**11.157**	**6.600**	**0.949**	**14.380**	**21.833**	**2.543**	**12.768**
G	**18.710**	**2.220**	**11.867**	**7.293**	**0.767**	**10.520**	**13.002**	**1.494**	**11.193**
BV	**25.600**	**3.750**	**14.703**	**6.357**	**1.001**	**15.720**	**15.978**	**2.376**	**15.212**
BG	**16.310**	**2.711**	**16.610**	**6.027**	**1.120**	**18.493**	**11.168**	**1.916**	**17.552**
TV	**20.580**	**2.869**	**13.950**	**5.130**	**0.947**	**18.433**	**12.855**	**1.908**	**16.192**
TG	**16.753**	**2.750**	**16.440**	**5.080**	**0.763**	**14.983**	**10.917**	**1.757**	**15.712**
BV2	**26.090**	**3.810**	**14.623**	**6.317**	**0.787**	**12.487**	**16.203**	**2.299**	**13.555**
BG2	**16.933**	**3.185**	**18.853**	**6.347**	**0.822**	**12.893**	**11.640**	**2.004**	**15.873**
TV2	**24.043**	**3.155**	**13.127**	**5.610**	**0.782**	**13.913**	**14.827**	**1.968**	**13.520**
TG2	**15.290**	**2.945**	**19.473**	**6.163**	**1.020**	**16.540**	**10.727**	**1.982**	**18.007**
B2V	**20.800**	**2.863**	**13.823**	**11.210**	**1.621**	**14.453**	**16.005**	**2.242**	**14.138**
B2G	**18.310**	**3.163**	**17.240**	**8.397**	**1.703**	**20.300**	**13.353**	**2.433**	**18.770**
T2V	**20.623**	**3.204**	**15.753**	**4.407**	**0.672**	**15.440**	**12.515**	**1.938**	**15.597**
T2G	**13.553**	**2.634**	**19.417**	**6.400**	**0.861**	**13.450**	**9.977**	**1.747**	**16.433**
LSD (0.05)	**2.478**	**0.424**	**1.215**	**1.464**	**0.224**	**0.977**	**1.409**	**0.235**	**0.763**

Data represent in Table 2 illustrate the effect of crop pure stand and their mixtures in green, dry yield and dry matter% at booting stage. The differences among treatments were highly significant. The highest value for green and dry yield for pure stands recorded by narbon vetch reached 45.473 and 6.528 ton ha^{-1} respectively at the first location. But the maximum dry matter % for pure stands reached 20.47 % recorded by barley at the second location. Regarding to the mixtures the highest green was 38.613 ton ha^{-1} obtained from barley/vetch 2:1 at the first location, but the highest dry yield reached 6.400 ton ha^{-1} from the mixture barley/grass pea 2:1 at the first location also. The highest dry matter % for crop mixtures recorded by barley/ vetch1:1 reached 20.89 % at the second location. Data in Table 3 explain the land equivalent ratio at stem elongation stage in mixtures at both locations. The effect of mixtures in this trait was highly significant. The highest value for total LER was 1.669 recorded by the mixture barley/grass pea 2:1 at the second location, while the lowest total LER was 0.734 for the mixture barley/vetch 1:2 at the second location. The maximum cereal LER was 0.991 exhibited by barley in the mixture barley/ vetch 2:1, and the lowest cereal LER was 0.335 for triticale in the mixture triticale/vetch 1:2 at the second location. The highest legume LER was 0.735recorded by grass pea in the mixture barley/ grass pea 2:1 at the second location, but the lowest legume LER value was 0.141 for grass pea in the mixture barley/ grass pea 2:1 at the first location.

Table 2. Effect of Crop pure stand and their mixtures on green, dry yield (ton h^{-1}) and dry matter (%) at booting stage for both locations and their average

Crop mixture	Kanipanka location			Qlyasan location			Average of both locations		
	Green yield ton ha^{-1}	Dry yield ton ha^{-1}	DM %	Green yield ton ha^{-1}	Dry yield ton ha^{-1}	DM %	Green yield ton ha^{-1}	Dry yield ton ha^{-1}	DM %
B	38.010	6.323	16.640	22.910	4.689	20.467	30.460	5.506	18.553
T	34.250	5.960	17.403	20.067	3.728	18.577	27.158	4.844	17.990
V	45.473	6.528	14.353	19.747	3.222	16.307	32.610	4.875	15.330
G	37.760	4.666	12.353	27.297	4.798	17.580	32.528	4.732	14.967
BV	35.940	5.340	14.873	20.747	4.334	20.893	28.343	4.837	17.883
BG	33.660	5.887	17.493	19.457	3.370	17.333	26.558	4.629	17.413
TV	32.137	4.157	12.933	19.527	3.778	19.347	25.832	3.967	16.140
TG	35.687	5.888	16.493	25.490	4.023	15.803	30.588	4.956	16.148
BV2	34.477	4.784	13.860	15.523	2.777	17.850	25.000	3.781	15.855
BG2	35.493	5.410	15.240	20.727	4.216	20.350	28.110	4.813	17.795
TV2	34.510	5.017	14.540	17.533	3.273	18.697	26.022	4.145	16.618
TG2	34.607	5.704	16.480	19.340	3.410	17.617	26.973	4.557	17.048
B2V	38.613	5.115	13.240	25.423	4.241	16.683	32.018	4.678	14.962
B2G	36.817	6.400	17.383	27.350	4.832	17.667	32.083	5.616	17.525
T2V	37.577	5.127	13.640	23.233	3.750	16.180	30.405	4.439	14.910
T2G	35.533	5.713	16.080	23.877	4.603	19.277	29.705	5.158	17.678
LSD (0.05)	1.625	0.378	0.708	2.335	0.445	0.912	1.393	0.286	0.565

Table 3. Land equivalent ratio value (LER) at stem elongation stage in mixtures of barley and triticale with vetch and grass pea at both location and their average

Crop mixture	Kanipanka location			Qlyasan location			Average of both locations		
	Total LER	Cereal LER	Legume LER	Total LER	Cereal LER	Legume LER	Total LER	Cereal LER	Legume LER
BV	1.066	0.713	0.352	0.879	0.624	0.255	0.972	0.668	0.304
BG	0.986	0.521	0.464	1.053	0.702	0.351	1.02	0.612	0.408
TV	0.901	0.458	0.443	1.124	0.584	0.540	1.012	0.521	0.491
TG	1.215	0.614	0.602	0.998	0.503	0.495	1.106	0.558	0.548
BV2	1.081	0.714	0.367	0.734	0.353	0.382	0.907	0.533	0.374
BG2	1.079	0.775	0.304	0.822	0.430	0.393	0.951	0.603	0.348
TV2	1.006	0.539	0.467	0.905	0.335	0.569	0.955	0.437	0.518
TG2	1.378	0.770	0.608	1.423	0.842	0.581	1.401	0.806	0.595
B2V	0.778	0.400	0.378	1.437	0.991	0.445	1.108	0.696	0.412
B2G	1.022	0.882	0.141	1.669	0.934	0.735	1.346	0.908	0.438
T2V	1.142	0.826	0.317	0.845	0.686	0.160	0.994	0.756	0.238
T2G	1.163	0.780	0.383	1.127	0.649	0.479	1.146	0.715	0.431
LSD (0.05)	0.154	0.137	0.120	0.351	0.208	0.186	0.186	0.121	0.108

Data in Table 4 illustrate the land equivalent ratio at booting stage; it was observed that the effect of crop mixtures in this trait was highly significant. The greatest total LER was 1.139 recorded by both mixtures barley/grass pea 2:1at the first location and triticale/grass pea 2:1 at second locations. The lowest total LER value was 0.667 recorded by triticale/vetch 1:1 at the first location. The maximum LER_{cereal} value was 0.797 for barley in the mixture barley/grass pea 2:1 at the second location, but the lowest value was 0.217 for barley in the mixture barley/vetch 1:2 at the second location. Maximum LER_{legume} value was 0.661 recorded by vetch in the mixture triticale/vetch 1:1 at the second location, while the lowest value was 0.176 for grass pea in the mixture barley/grass pea 1:1 at the second location.

Table 4. Land equivalent ratio value (LER) at stem booting stage in mixtures of barley and triticale with vetch and grass pea at both location and their average

Crop mixture	Kanipanka location			Qlyasan location			Average of both locations		
	Total LER	Cereal LER	Legume LER	Total LER	Cereal LER	Legume LER	Total LER	Cereal LER	Legume LER
BV	0.835	0.528	0.307	1.065	0.623	0.442	0.950	0.576	0.374
BG	1.066	0.555	0.511	0.715	0.539	0.176	0.891	0.547	0.344
TV	0.667	0.339	0.328	1.104	0.444	0.661	0.886	0.391	0.494
TG	1.109	0.560	0.549	1.012	0.777	0.235	1.061	0.669	0.392
BV2	0.742	0.304	0.439	0.767	0.217	0.550	0.754	0.260	0.494
BG2	0.996	0.463	0.532	0.893	0.586	0.307	0.944	0.525	0.420
TV2	0.795	0.298	0.497	0.956	0.379	0.576	0.875	0.339	0.537
TG2	1.118	0.637	0.482	0.834	0.464	0.371	0.976	0.550	0.426
B2V	0.799	0.509	0.290	1.075	0.532	0.544	0.937	0.520	0.417
B2G	1.139	0.661	0.478	1.023	0.797	0.226	1.081	0.729	0.352
T2V	0.818	0.368	0.450	1.083	0.525	0.558	0.951	0.447	0.504
T2G	1.074	0.552	0.521	1.139	0.794	0.346	1.106	0.673	0.434
LSD (0.05)	0.107	0.048	0.094	0.143	0.080	0.092	0.087	0.045	0.064

Data in table 5 illustrate the relative crowding coefficient RCC or K at elongation stage. The differences among crop mixtures were highly significant due to this trait. The highest K_{total} reached 2.424 for the mixture triticale/grass pea 1:1 at the first location, while the lowest value was 0.037 for the mixture triticale/vetch 2:1 at the second location. The greatest K_{cereal} reached 2.834 for barley in the mixture barley/grass pea1:1 at the second location, while the lowest value was 0.174 for barley in the mixture barley/vetch 2:1 at the first location. The maximum K_{legume} was 1.558 for grass pea in the mixture triticale/grass pea 1:1 in the first location, but the lowest K_{legume} value was 0.119 for vetch in the mixture triticale/vetch 2:1 at the second location.

Table 5. The relative crowding coefficient (RCC) or (K) at elongation stage for all crop mixture at both locations and their average

Crop mixture	Kanipanka Location			Qilyasan Location			Average of both locations		
	K total	K cereal	K legume	K total	K cereal	K legume	K total	K cereal	K legume
BV	1.362	2.500	0.544	0.668	1.796	0.348	1.015	2.148	0.446
BG	0.943	1.096	0.871	1.638	2.834	0.566	1.291	1.965	0.718
TV	0.681	0.856	0.810	1.885	1.433	1.251	1.283	1.145	1.030
TG	2.424	1.610	1.558	1.174	1.075	1.011	1.799	1.343	1.285
BV2	0.099	0.617	0.160	0.046	0.264	0.172	0.073	0.440	0.166
BG2	0.090	0.669	0.133	0.055	0.320	0.174	0.073	0.495	0.153
TV2	0.093	0.465	0.203	0.066	0.251	0.256	0.080	0.358	0.230
TG2	0.175	0.660	0.265	0.170	0.660	0.257	0.172	0.660	0.261
B2V	0.057	0.174	0.326	0.145	0.437	0.333	0.101	0.306	0.330
B2G	0.048	0.384	0.122	0.226	0.412	0.550	0.137	0.398	0.336
T2V	0.096	0.360	0.273	0.037	0.295	0.119	0.067	0.328	0.196
T2G	0.113	0.340	0.330	0.102	0.286	0.357	0.108	0.313	0.344
LSD (0.05)	0.173	0.206	0.245	0.845	0.865	0.340	0.419	0.432	0.204

Data in table 6 explain the relative crowding coefficient RCC or K at booting stage. Highly significant differences were present among crop mixtures for this trait. The highest K_{total} was 1.652 for the mixture triticale/vetch1:1 at the first location, but the lowest value for this trait was 0.066 for the mixture barley/grass pea 2:1 at the second location. The highest K_{cereal} was 3.538 for triticale in the mixture triticale/grass pea 1:1at the second location, but the lowest value for K_{cereal} was 0.154 for barley in the mixture barley/vetch 1:2 at the second location. The maximum value for K_{legume} was 1.968 for vetch in the mixture triticale/vetch 1:1 in the second location, but the lowest value was 0.161 for grass pea in the mixture barley/grass pea 2:1 at the second location.

Table 6. The relative crowding coefficient (RCC) or (K) at booting stage for all crop mixture at both locations and their average

Crop mixture	Kanipanka Location			Qlyasan Location			Average of both locations		
	K total	K cereal	K legume	K total	K cereal	K legume	K total	K cereal	K legume
BV	0.495	1.121	0.445	1.366	1.667	0.820	0.931	1.394	0.632
BG	1.319	1.248	1.060	0.253	1.185	0.214	0.786	1.217	0.637
TV	0.251	0.513	0.488	1.564	0.800	1.968	0.908	0.657	1.228
TG	1.652	1.293	1.241	1.097	3.538	0.308	1.374	2.415	0.775
BV2	0.045	0.223	0.204	0.047	0.154	0.292	0.046	0.189	0.248
BG2	0.084	0.340	0.248	0.068	0.417	0.162	0.076	0.378	0.205
TV2	0.050	0.218	0.231	0.080	0.270	0.299	0.065	0.244	0.265
TG2	0.148	0.660	0.225	0.129	0.660	0.195	0.139	0.660	0.210
B2V	0.050	0.236	0.213	0.108	0.278	0.387	0.079	0.257	0.300
B2G	0.108	0.308	0.351	0.066	0.417	0.161	0.087	0.362	0.256
T2V	0.056	0.171	0.330	0.109	0.274	0.397	0.083	0.223	0.363
T2G	0.099	0.257	0.383	0.101	0.410	0.246	0.100	0.333	0.314
LSD (0.05)	0.356	0.127	0.186	0.310	0.332	0.194	0.229	0.173	0.130

Data represent in table 7 indicate to the values of competitive ratio (CR) of crop mixtures at elongation stage for both locations and their average. The differences among crop mixtures due to this trait were highly significant. The maximum CR $_{cereals}$ value was 5.122 recorded by barley in the mixture barley/grass pea 1:2 at the first location, but the minimum CR $_{cereal}$ value was 0.529 at the same location exhibited by barley in the mixture barley/vetch 2:1. Concerning to CR of legumes, the greatest value for this trait was 1.919 exhibited by vetch in the mixture barley/vetch 2:1 at the first location, but the lowest value of CR legume was 0.196 for grass pea in the mixture barley/grass pea 1:2 at the first location. Data recorded on competitive ratio (CR) for crop mixtures at booting stage represented in table 8 for both location and their average. The differences among crop mixtures were highly significant respect to this trait. The maximum value for CR $_{cereal}$ was 3.820 recorded by barley in the mixture barley/grass pea 1:2, at the second location, but the lowest value was o.412 for triticale on the mixture triticale/vetch 2:1 at the first location.

Table 7. Competitive ratio (CR) Values for crop mixtures at elongation stage for both seasons and their average

Crop mixture	Kanipanka location		Qilyasan location		Average of both locations	
	CR Cereal	CR Legume	CR Cereal	CR Legume	CR Cereal	CR Legume
BV	2.026	0.494	2.457	0.408	2.242	0.451
BG	1.130	0.895	2.065	0.505	1.598	0.700
TV	1.057	0.979	1.098	0.918	1.078	0.948
TG	1.033	0.989	1.008	0.996	1.021	0.993
BV2	3.901	0.210	1.909	0.208	2.905	0.209
BG2	5.122	0.196	2.183	0.478	3.652	0.337
TV2	2.390	0.443	1.197	0.842	1.793	0.642
TG2	2.725	0.409	3.087	0.337	2.906	0.373
B2V	0.529	1.919	1.154	0.916	0.842	1.417
B2G	3.335	0.313	0.638	1.575	1.987	0.944
T2V	1.367	0.806	2.116	0.525	1.742	0.665
T2G	1.021	0.991	0.676	1.482	0.848	1.237
LSD (0.05)	0.879	0.246	0.592	0.189	0.515	0.151

Table 8. Competitive ratio (CR) Values for crop mixtures at booting stage for both seasons and their average

Crop mixture	Kanipanka locatin		Qilyasan location		Average of both locations	
	CR cereals	CR Legume	CR cereals	CR Legume	CR cereals	CR Legume
BV	1.739	0.582	1.449	0.712	1.594	0.647
BG	1.091	0.923	3.064	0.330	2.078	0.626
TV	1.035	0.967	0.675	1.492	0.855	1.230
TG	1.022	0.978	3.308	0.302	2.165	0.640
BV2	1.393	0.331	0.799	0.345	1.096	0.338
BG2	1.749	0.577	3.820	0.263	2.785	0.420
TV2	1.199	0.836	1.326	0.767	1.263	0.802
TG2	2.815	0.379	2.537	0.399	2.676	0.389
B2V	0.879	1.149	0.490	2.045	0.685	1.597
B2G	0.696	1.445	1.808	0.568	1.252	1.006
T2V	0.412	2.456	0.474	2.127	0.443	2.292
T2G	0.533	1.888	1.145	0.885	0.839	1.386
LSD (0.05)	0.448	0.224	0.382	0.177	0.286	0.139

Data in table 9 explain the aggressive (A) of crop mixtures for cereals and legumes at both locations and their average. The differences among crop mixtures were highly significant for this trait. The highest A_{cereal} value recorded by barley in the mixture barley/grass pea 2:1 reached 2.458 at the first location and followed by 2.329 for barley also in the mixture barley/vetch 2:1 at the second location. Regarding to A_{legume} all crop mixtures produced a negative value indicating that the cereals were more dominant over the legumes in all crop mixtures at elongation stage.

Table 9. Aggressive (A) for mixtures of barley and triticale with vetch and grass pea at elongation stage for both locations and their average

Crop mixture	Kanipanka location		Qilyasan location		Average of both locations	
	ACereal	ALegume	ACereal	ALegume	ACereal	ALegume
BV	0.722	-0.722	0.736	-0.736	0.729	-0.729
BG	0.114	-0.114	0.702	-0.702	0.408	-0.408
TV	0.031	-0.031	0.089	-0.089	0.060	-0.060
TG	0.024	-0.024	0.016	-0.016	0.020	-0.020
BV2	1.608	-1.608	0.491	-0.491	1.049	-1.049
BG2	1.888	-1.888	0.708	-0.708	1.298	-1.298
TV2	0.927	-0.927	0.153	-0.153	0.540	-0.540
TG2	1.412	-1.412	1.672	-1.672	1.542	-1.542
B2V	0.641	-0.641	2.329	-2.329	1.485	-1.485
B2G	2.458	-2.458	1.716	-1.716	2.087	-2.087
T2V	2.022	-2.022	1.834	-1.834	1.928	-1.928
T2G	1.785	-1.785	1.240	-1.240	1.512	-1.512
LSD (0.05)	0.500	0.500	0.513	0.513	0.348	0.348

Data represented on Aggressivity at booting stage present in table 10 showed that the differences among crop mixtures were highly significant. The maximum value for A_{cereal} was 2.073 exhibited by barley in the mixture barley/grass pea 2:1 in the second location, and followed by 1.676 for also barley in the same mixture at the average of both locations. Regarding to the legumes, it was indicated that most A values were negative, this indicated the superiority of cereals over legumes in booting stage also.

Table 10. Aggressivity (A) for mixtures of barley and triticale with vetch and grass pea at booting stage for both locations and their average

Crop mixture	Kanipanka location		Qilyasan location		Average of both locations	
	A_{Cereal}	A_{Legume}	A_{Cereal}	A_{Legume}	A_{Cereal}	A_{Legume}
BV	0.443	-0.443	0.362	-0.362	0.402	-0.402
BG	0.087	-0.087	0.725	-0.725	0.406	-0.406
TV	0.022	-0.022	-0.433	0.433	-0.206	0.206
TG	0.024	-0.024	1.084	-1.084	0.554	-0.554
BV2	0.256	-0.256	-0.175	0.175	0.041	-0.041
BG2	0.597	-0.597	1.309	-1.309	0.953	-0.953
TV2	0.149	-0.149	0.278	-0.278	0.213	-0.213
TG2	1.198	-1.198	0.845	-0.845	1.022	-1.022
B2V	1.102	-1.102	0.787	-0.787	0.945	-0.945
B2G	1.279	-1.279	2.073	-2.073	1.676	-1.676
T2V	0.436	-0.436	0.747	-0.747	0.591	-0.591
T2G	0.883	-0.883	1.880	-1.880	1.382	-1.382
LSD (0.05)	0.197	0.197	0.227	0.227	0.146	0.146

Tables 11 illustrate the actual yield loss of cereals, legumes and inter-crops at elongation stage for both locations and their average. The differences among crop mixtures were highly significant for all components. Maximum value for total AYL was 1.642 of the mixture barley/grass pea 2:1 at the second location, while the maximum AYL for cereals was 1.552 recorded by triticale in the mixture triticale/grass pea 1:2 at the second location also. The greatest value for AYL of legumes reached 1.227 recorded by grass pea in the mixture barley/grass pea 2:1 at the second location

Table 11. Actual yield loss of cereals, legumes and intercrops at both locations and their average during elongation stage

Crop mixture	Kanipanka location		Qilyasan location		Average of both locations	
	A_{Cereal}	A_{Legume}	A_{Cereal}	A_{Legume}	A_{Cereal}	A_{Legume}
BV	0.443	-0.443	0.362	-0.362	0.402	-0.402
BG	0.087	-0.087	0.725	-0.725	0.406	-0.406
TV	0.022	-0.022	-0.433	0.433	-0.206	0.206
TG	0.024	-0.024	1.084	-1.084	0.554	-0.554
BV2	0.256	-0.256	-0.175	0.175	0.041	-0.041
BG2	0.597	-0.597	1.309	-1.309	0.953	-0.953
TV2	0.149	-0.149	0.278	-0.278	0.213	-0.213
TG2	1.198	-1.198	0.845	-0.845	1.022	-1.022
B2V	1.102	-1.102	0.787	-0.787	0.945	-0.945
B2G	1.279	-1.279	2.073	-2.073	1.676	-1.676
T2V	0.436	-0.436	0.747	-0.747	0.591	-0.591
T2G	0.883	-0.883	1.880	-1.880	1.382	-1.382
LSD (0.05)	0.197	0.197	0.227	0.227	0.146	0.146

Data recorded on actual yield loss at booting stage was representing in table 12 there were highly significant differences among crop mixtures for this trait. The maximum value for AYL total was 0.658 recorded by the mixture triticale/grass pea1:2 at the first location, but the highest value for AYL cereal reached 0.775 obtained by barley in the mixture barley /grass pea1:2 at the second location. Regarding to the legumes the highest AYL of legumes was 0.690 recorded by vetch in the mixture triticale/vetch 2:1 at the second location.

Table 12. Actual yield loss of cereals, legumes and inter-crops at both locations and their average during booting stage

Crop mixture	Kanipanka L.			Qilyasan L.			Average of both locations		
	AYL total	AYL Cereal	AYL Legume	AYL total	AYL Cereal	AYL Legume	AYL total	AYL Cereal	AYL Legume
BV	-0.330	0.056	-0.386	0.130	0.246	-0.116	-0.100	0.151	-0.251
BG	0.132	0.109	0.022	-0.569	0.078	-0.647	-0.219	0.093	-0.313
TV	-0.667	-0.322	-0.345	0.209	-0.112	0.321	-0.229	-0.217	-0.012
TG	0.219	0.121	0.098	0.024	0.554	-0.530	0.122	0.337	-0.216
BV2	-0.416	-0.080	-0.336	-0.510	-0.342	-0.167	-0.463	-0.211	-0.252
BG2	0.210	0.404	-0.193	0.240	0.775	-0.535	0.225	0.589	-0.364
TV2	-0.345	-0.098	-0.247	0.023	0.150	-0.128	-0.161	0.026	-0.187
TG2	0.658	0.928	-0.270	-0.033	0.406	-0.439	0.313	0.667	-0.354
B2V	-0.349	-0.229	-0.120	0.453	-0.195	0.647	0.052	-0.212	0.264
B2G	0.450	0.002	0.449	-0.107	0.208	-0.315	0.171	0.105	0.067
T2V	-0.079	-0.442	0.362	0.486	-0.204	0.690	0.203	-0.323	0.526
T2G	0.417	-0.164	0.580	0.250	0.202	0.048	0.333	0.019	0.314
LSD (0.05)	0.207	0.098	0.180	0.291	0.166	0.185	0.174	0.093	0.125

Data in table 13 illustrate the effect of location on fresh, dry yield and dry matter % at both elongation and booting stage. The differences between locations were highly significant for all traits at both stages with the exception of dry matter% at elongation stage, which was not significant. During elongation stage the Kanipanka location predominated the Qlyasan location high significantly in both fresh and dry yield by 68.0 % and 67.7 % respectively. At booting stage also Kanipanka exceeded Qlyasan location in both traits fresh and dry yield high significantly by 40.0 % and 28.4% respectively, this confirm the suitability of the first location more than the other for these traits, this may be due to agreement of the environment condition prevailing in the first locating in term of temperature, lighting and other factors at both stages of growth. At the second stage it was indicated the out yielding the second location in dry matter over the first location by 16.38%.

Table 13. Effect of location on fresh, dry yield and dry matter % at both stages

Location	Fresh yield ton ha^{-1}	Dry yield ton ha^{-1}	D.M%
Elongation stage			
Kanipanka	20.311	3.056	15.568
Qlyasan	6.494	0.987	15.195
LSD	3.468	0.4308	N.S
Booting stage			
Kanipanka	36.284	5.501	15.188
Qlyasan	21.765	3.940	18.164
LSD	0.891	0.115	0.3248

Data represent in table 14 explain the effect of location on all competition indices (LER, Aggerssivity(A),Relative crowding coefficient(K), Competitive ratio(CR)and Actual yield loss(AYL). The effect of locations was found to be significant on only partial LER $_{legume}$, CR $_{cereal}$ and partial AYL $_{legume}$ at elongation stage, but at booting stage the effect of locations was significant for LER $_{cereal}$, A $_{cereal}$ and A $_{legume}$, K $_{cereal}$, CR $_{cereal}$ and CR $_{legume}$ and AYL $_{cereal}$. At elongation stage the Qlyasan location exceeded Kanipanka location in the trait LER $_{legume}$, AYL $_{cereal}$, but Kanipanka location predominated Qlyasan location in CR_{cereal}. At booting stage the Kanipanka location predominated Qlyasan location in A $_{legume}$ and CR $_{legume}$, but Qlyasan location recorded dominant value camper to Kanipanka location in LER $_{cereal}$, A $_{cereal}$, K $_{cereal}$, CR $_{cereal}$ and AYL $_{cereal}$

Table 14. Effect of locations on LER, Aggressivity, Relative crowding coefficient, Competitive ratio, Actual yield loss

Elongation stage													
Location	LER			Aggressivity		Relative crowding coefficient			Competitive ratio		Actual yield loss		
	LER cereal	LER legume	LER total	A_{Cereal}	A_{legume}	K cereal	K legume	K avarage	CR cereal	CR legume	AYL cereal	AYL Legume	AYL total
Kanipanka	0.666	0.402	1.068	1.136	-1.136	0.811	0.466	0.515	2.136	0.720	0.456	-0.162	0.294
Qlyasan	0.636	0.449	1.085	0.974	-0.974	0.839	0.449	0.518	1.632	0.766	0.309	-0.024	0.284
LSD	N.S	0.030	N.S	N.S	N.S	N.S	N.S	N.S	0.452	N.S	N.S	0.056	N.S
Booting stage													
Location	LER			Aggressivity		Relative crowding coefficient			Competitive ratio		Actual yield loss		
	LER cereal	LER legume	LER total	A_{Cereal}	A_{legume}	K cereal	K legume	K avarage	CR cereal	CR legume	AYL cereal	AYL Legume	AYL total
Kanipanka	0.481	0.449	0.930	0.540	-0.540	0.549	0.452	0.363	1.214	1.043	0.024	-0.032	-0.008
Qlyasan	0.556	0.416	0.972	0.790	-0.790	0.839	0.454	0.416	1.741	0.853	0.147	-0.098	0.050
LSD	0.037	N.S	N.S	0.15192	0.15192	N.S	N.S	0.126	0.192	0.111	N.S	N.S	0.103

Results in that applied inter cropping system affected green, dry yield and dry matter % significantly. It was confirmed that barley and triticale are crops which can be used as mono crops or in mixture system with legumes if the harvest date was adjusted for the forage to match the quantity and quality of the resulting mixture. There are a few numbers of mixtures that are superior to monoculture in both green and dry forage yields. The superiority of barley over triticale in forage yield (green and dry) during both cutting dates and both locations in monoculture and mixtures can be interpreted by the vigor growth of barley in the early stage of its life cycle compare to triticale. Many studies have reported a yield increase of forage cereal/legume inter crops compare to cereal sole crops (7, 8, 20). The mixtures barley/grass pea and triticale/vetch 2:1 showed its superiority over the other mixtures at both locations and both cutting. The greater yield was found in the cereal/legume mixtures, which had the highest proportion of legume (25). Barley/legume inter crops produced the highest dry matter yield reported by (28). In contrast (9,34) confirmed no yield improvement in cereal/ legume forage mixtures compared to cereal forage sol crops. In many cases, it has been indicated that yields of mixtures between cereals and legumes were intermediate or even lower than yields of monocultures due to competition between the inter-cropped species (18, 33).It was revealed that two crops can be grown at the same field and the risk of growing one crop can be eliminated(1).The superiority of the second harvesting stage was more clear compare to the first stage indicating that the delaying of cutting stage leads to an increase in the yield of green forage, and the reason may be due to the increase in plant height, increase in leaf area and accumulation of dry matter in the later stages of cutting (16, 15). The Highly significant differences among crop mixtures were noticed due to LER at both locations and both cutting stage. In most cases the partial LER_{legume} less than partial $LER_{cereals}$ at both cutting stages and both locations. The best values of total LER produced by the crop mixtures triticale/grass pea 1:2 and barley/grass pea 2:1 which were more than unity. Yield advantage in term of LER_{total} was greatest in the case of vetch/Triticale mixture (1.00) and vetch/barley mixture (1.03) when the forage harvested at stem elongation, whereas grass pea mixtures with barley and triticale recorded the greatest values at the booting stage (1.07 and 1.09) respectively (23). Yield advantage in terms of total LER was greatest in the cases pea/barley mixture (34, 14) and vetch/barley mixture (34, 11), this indicates an advantage from intercropping over pure stands in terms of the use of environmental resources for plant growth and better land utilization (4, 11). Regarding to the relative crowding coefficient (RCC or K)

value, the K value of cereals were greater than those of legumes in more cases at both cutting stages indicating the dominance of cereals under these crop mixtures. Similarly (11) found that barley and triticale were the dominant species in mixtures with common vetch. The K_{total} was more than one in all cutting dates except for the barley/grass pea mixture in the first cutting date, which indicated a definite yield advantage due to intercropping (5). The partial K_{value} of barley were higher than partial K of legumes in the case of grass pea75/barley25, vetch75/barley25 and vetch50/barley50 inter-crops, this indicates that barley is more competitive than associated crops (11). In vetch 25/barley75 mixture, the K_{value} was below one, which indicates that there was a yield disadvantage (12). Concerning to competitive ratio (CR) value for crop mixtures, the competitive ratio of cereals was greater than those of legumes in most cases of crop mixtures, indicating that cereals are more competitive than legumes. Inter-cropped grass pea and vetch had higher competitive in barley50/grass pea50, barley75/grass pea25 and barley75/vetch25 mixtures respectively, indicating that grass pea and vetch is more competitive than barley in these cases. However, in all other mixtures the value of CR for barley was greater than for legumes indicating the dominance of barley under these mixtures. Moreover the value of CR for grass pea was greater than vetch in all mixtures. This indicates that grass pea was more competitive than vetch (13). Aggressivity is another index that is often used to indicate how much the relative yield increase in "a" crop is greater than that of "b" crop in an inter cropping system (20). Generally cereals recorded positive aggressivity, while the legume species showed negative aggressivity values in most cases at both cutting stages. This indicate that cereals were most competitive than legumes and they are the dominant species as measured by the positive value of aggressivity (2, 24) suggested that cereals may not always be the dominant crops the intercropping with legumes. AYL cereals had positive values in most crop mixtures, which indicate a yield advantage for cereals because of the positive effect of legume on cereals when grown in association. These results were in a good agreement with those reported by (5, 11). Quantification of yield loss or gain due to association with other species could not be obtained through partial LER, where as partial AYL shows the yield loss or gain by its sign and as well as its value (11). The superiority of Kanipanka location in forage yield may be due to the suitability of environmental condition across vegetative growth stage especially the temperature in compare to Qlyasan location (29),while some workers 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 its distribution and also the presence of better temperature during growth stage (30).

CONCLUSION

The greater contribution of legumes was found when common vetch and grass pea were mixed with triticale than with barley. Aggressivity values indicated that triticale and barley were the dominant species in the intercropping system.The system 1cereal : 2legumes were more effective among the studied systems on forage yield and, followed by 1cereal : 1legume system. The predominant of Kanipanka location compared to Qlyasan in green and dry forage characters had explained the suitability of Kanipanka in environmental condition during the growing stage of these crops. Intercropping may lead to a better uses of different limiting production factors, and among them land, time and available financing capacities, than separated monocultures, therefore, land equivalent ratio LER was used to increase production in volume or value through intercropping relative to the respective sole crops.

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