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EVALUATION OF BARLEY, FENUGREEK AND VETCH MIXTURES UNDER RAINFED CONDITIONS IN THE NORTH WESTERN COAST OF EGYPT

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ABSTRACT

Mixtures of barley with winter annual forage legumes are extensively used under rainfed and semiarid systems of the Mediterranean region for forage production. Three winter seasons field studies (2004/2005, 2005/2006 and 2006/2007) at Ras Al-Hekma, north western coast of Egypt was conducted using barley, vetch and fenugreek monoculture as well as mixtures of barley with each of the above forage legumes, in three seeding ratios (75:25, 50:50 and 25:75) to investigate forage yield and its quality as well as the effect of mixtures on the growth rate of the three species used in the experimental trials. Barley monoculture as well as both barley-vetch (75:25) and barley-fenugreek (75:25) provided greater forage yield than other mixtures and sole vetch and fenugreek. Land Equivalent Ratio (LER) was increased by monocultures than mixtures. Highest protein percentage and yield were achieved when fenugreek and vetch were grown as a monoculture. Barley was achieved the highest nutritive value (NV), total digestible nutrients (TDN) and Net energy (NE). Gross energy (GE) was not reached the significant levels.

Key worlds: Forage mixtures, Forage quality, Gross energy, Land equivalent ratio and Nutritive value.

INTRODUCTION

Grass-legume mixtures may have the advantage of stabilizing yield over the growing seasons, which may be more important than achieving high yields, especially in Mediterranean rainfed condition characterized by strong inter- and intra annual meteorological

fluctuations and the extremely high heterogeneity of environmental and farming system situations (Porqueddu et al., 2008). Barley grains, straw and residuals are produced by Bedouins as supplements roughages for livestock. Barley, as a source for both forage and grain production proved to be the most adaptable crop under rainfed conditions of the desert areas, specially at north western coast area of Egypt (Moselhy and El-Hakeem 2001). Fenugreek has an exciting potential effect as an alfalfa alternative in this respect, Dhima et al., 2007 and Shaheen, 1989 showed that, intercropping wheat with fenugreek produced the highest values of wheat yield under pure stand. El-Banna (1998) found that the intercropping wheat with fenugreek decreased significantly wheat yield. While, the results of Moselhy and El-Hakeem (2001) indicated that the barley pure stand produced the highest fresh and dry forage yields followed by the mixture of barley and vetch for 75% and 25% respectively.

The objectives of the present work were: (i) to evaluate barley (*Hordeum vulgare* L), fenugreek (*Trigonella foenum-graecum* L.) and vetch (*Vicia monantha* L.) monocultures as well as mixtures of barley with each of fenugreek and vetch by three seeding ratios (75:25, 50:50 and 25:75, respectively) for forage yield and quality, (ii) to study the effect of mixture on growth rate of the three species at the three seeding rates and (iii) chemical composition, forage quality and nutritive values of the studies factors.

MATERIALS AND METHODS

Three farm trials were carried out under dryland management and rainfed conditions during winter growing seasons of 2004/2005, 2005/2006 and 2006/2007 at Ras Al-Hekma, north western coast of Egypt . The experiments were established in loamy-sand soil with pH 7.5; it has 0.019% available nitrogen, 20 ppm phosphorus and high $CaCo_3$ content (26% at 0 to 30 cm depth). The experimental site is only sown in winter season due to limit winter precipitation. Climatic data during the three growing seasons are given in Table 1. Seedbed preparation including ploughing twice using a chisel plow. Nitrogen and P_2O_5 at 30 and 15 kg ha^{-1}, respectively, were incorporated into the soil before sowing. Barley (*Hordeum vulgare* L) cv Giza 123, fenugreek (*Trigonella foenum-graecum* L.) and vetch (*Vicia monantha* L.) were sown broadcasting in the soil. The seeding rate of barley was 70 kg h^{-1} (hectare = h = 10000 m^{-2} = 2.38 feddan) while, the seeding

rate for fenugreek and vetch were 35 kg h^{-1}, the seeds were mixed and sown broadcasting together.

Table 1. The meteorological data of Marsa Matrouh district during the three growing seasons.

Month	Average Temperature			2004/05			2005/06			2006/07		
	Max	Min	Mean	Rel.H. %	Prec. mm.	WS m/s	Rel.H. %	Prec. mm.	WS m/s	Rel.H. %	Prec. mm.	WS m/s
November	16.6	11.5	14.05	64.3	22.6	3.9	63.8	26.5	3.5	64.4	22.6	3.7
December	15.3	09.4	12.35	71.2	25.0	3.4	71.3	21.2	2.9	71.5	28.5	3.8
January	13.3	09.2	11.25	74.4	24.0	4.8	73.0	22.9	4.4	69.7	18.1	4.2
February	14.6	11.2	12.90	70.6	22.0	4.6	71.0	20.0	3.6	69.7	31.5	5.4
March	17.9	13.5	15.70	60.3	26.9	3.9	60.7	14.3	3.6	60.3	5.3	5.1
April	21.3	15.2	18.25	62.8	00.0	4.0	63.8	00.0	4.0	68.7	2.0	4.9
May	25.6	17.8	21.70	75.5	00.0	3.7	76.1	00.0	3.4	70.0	0.0	4.8
Average	17.8	12.5	15.2	68.4	120.5	4.0	68.5	104.9	3.6	67.8	108.0	5.6

Where Rel. H. % = Relative humidity (%), Prec.: precipitations (mm), WS: wind speed (m/sec.)

The mixture and monocultures replacements triad were as follows:

1. 100% barley (pure stand of barley)
2. 100% fenugreek (pure stand of fenugreek)
3. 100% vetch (pure stand of vetch)
4. 75% barley + 25% fenugreek
5. 50% barley + 50% fenugreek
6. 25% barley + 75% fenugreek
7. 75% barley + 25% vetch
8. 50% barley + 50% vetch
9. 25% barley + 75% vetch

Germination percentage (In laboratory) for fenugreek and vetch ranged from 50 to 60% before sowing, for thus were soaked in water for 24 hour before sowing, with changing the soaking water every 12 hr. to raise their germination percentage.

Over the three seasons, the barley, fenugreek and vetch seeds were sown on November after effective precipitation.

The Land Equivalent Ratio (LER) was calculated according to (Willey and Osiru 1972) as follows:

$LER = L_{(Legume)} + L_{(Grasse)}$, where:

$L_{(Legume)}$ - Yield of legume crop in mixture / yield of sole same legume crop

$L_{(Grasse)}$ - Yield of barley in mixture / yield of sole barley

The chemical composition were determined in dry matter by oven dried the fresh at 65 °C to a constant weight (A.O.A.C, 1990). Samples were milled to fine powder and used for the chemical analyses. Crude protein (CP) was determined by using modified Micro- Kjeldahl according to Peach and Tracey (1956) to measure total nitrogen which was then multiplied by 6.25. Crude fiber (CF) determination by using the filtration method, alkali and acid treatments samples were filtered through a mat. The ring adjusted to an ordinary funnel attached to a vacuum pump according to A.O.A.C. (1990). Ash content was determined in the samples by a process similar to cremation in a muffle furnace at 600 ^{O}C for five hours and the residual minerals (inorganic material) were determined according to A.O.A.C. (1990). The ether extracted (EE) determining by using petroleum ether at 60 – 80 °C in Soxhelt apparatus according to A.O.A.C. (1990). Nitrogen free extract (NFE) was calculated as follows: NFE % = 100 - (CP % + CF % + EE % + ash %).

The Total digestible nutrients (TDN) (%in DM) = 0.62 (100+1.25 EE) – CP 0.72, where EE is % of ether extract, and CP is % of crude protean, and nutritive value (NV) was calculated as follows NV (%in DM) = TDN/CP (Abu El-Naga and El-Shazly, 1971).

Gross energy (GE) calculated according to MAFF (1975) using the following equation GE, MJ kg^{-1} DM= 0.0226 CP + 0.0407 EE + 0.0192 CF + 0.0177 NFE. Net energy (NE) was estimated as follows (Riviere 1977): NE ($MJkg^{-1}$ DM) = [(TDN% x 3.65- 100)/188.3] x 6.9.

The present farm trials were laid out in Randomized Complete Blocks design (RCB) with four replicates. Plot size was (4x5m) 20 m^2. The collected data were statistically analyzed according to Snedecor and Cochran (1980) by using MSTAT-C, (Russell, 1991), treatment mean differences were separated by the least significant difference (LSD) test at the 0.05 probability level

RESULTS AND DISCUSSION

Fresh and dry forage yield: the treatment means across the growing three seasons are presented in Table 2. The greatest forage yield was obtained from barley planted as monoculture. However, the yield of pure stands of fenugreek and vetch were significantly lower than of all mixtures and barley pure stand yields (Table2).

Table 2. Fresh, dry and relative yields of monocultures and mixtures of barley with fenugreek or vetch at different seeding ratios.

Mixture sowings	Fresh	Dry	LER
100% barley	2.992	1.663	1.00
75%barley+25% fenugreek	2.478	1.340	0.920
50%barley+50% fenugreek	2.106	1.162	0.905
25%barley+75% fenugreek	1.753	0.940	0.873
100% fenugreek	1.581	0.871	1.00
75% barley + 25% vetch	2.521	1.403	0.935
50% barley + 50% vetch	2.161	1.217	0.899
25% barley + 75% vetch	1.877	1.063	0.903
100% vetch	1.773	1.006	1.00
Mean	2.138	1.185	0.937
$LSD_{0.05}$	0.614	0.044	

Means are averaged over three growing seasons (2004/05, 2005/06 and 2006/07).

It can be observed that the highest herbage yield (2.992 t. ha^{-1}) was attained from pure stands of barley while the lowest one (1.581 t. ha^{-1}) was achieved from fenugreek pure stands. In addition, the yields of different mixtures were more productive than pure fenugreek or vetch. Dry yields also had similar results like herbage yield. Hence, the highest and the lowest dry matter yield were 1.663 t. ha^{-1} and 0.871 t. ha^{-1} for pure barley and pure fenugreek, respectively. The effect of mixture ratio was significantly pronounced the yield of herbage and dry matter yields (Table 1).

The best results in term of herbage and dry matter (DM) were taken from barley monoculture and mixtures (25% vetch + 75% barley) being followed by (25% fenugreek + 75 % barley), (50% vetch + 50% barley) respectively, (Table 2). It can be concluded that there was progressive and significant increase ($P<0.05$) in herbage and dry matter yield with the increase in barley ratio. The same results were found by Moselhy and El-Hakeem (2001). Yolcu, et al. 2009 found

that the sole common vetch, sole grass pea, sole barley and common vetch+ barley intercropping attained the highest yields.

Some researchers reported that yields of legume and cereal mixtures were intermediate or even lower than yields of monocultures due to competition between species (Roberts et al., 1989, Assefa and Ledin, 2001, Velazquez-Beltran et al., 2002, Karadag and Buyukburc, 2003, Lithourgidis et al., 2006).

Land Equivalent Ratio (LER):

Land equivalent ratio was used as a criterion for measuring of the efficiency of mixture advantage using the environment resources comparing with monocultures. When the value of LER is greater than one, the mixture favours the growth and yield of the species. When LER is lower than one, the mixture had negatively effects on the growth and yield (Muhamed et al, 2008). The LER of the studied mixtures exhibited an increasing trend as fenugreek or vetch proportion (Table 2). Monoculture production showed a yield advantage over all mixtures. These results are in agreement with those obtained of by Lithourgidis et al. (2006), who reported that, a mixed stand advantage at lower than monoculture.

Forage quality:

Crude protein (CP): of forage is one of the most important criteria for forage quality evaluation (Assefa and Ledin, 2001). In all studied mixtures, the CP content increased as fenugreek or vetch seeding proportion increased (Table3). Fenugreek monoculture had the highest CP % (19.16%) followed by vetch (18.37%) and the two mixtures (75:25) of fenugreek or vetch with barley (12.68 and 12.41 %, respectively) (Table3). Barley monoculture had the lowest CP % (7.41%).

Vetch and fenugreek pure stand had the highest CP yield (185 and 167 kg h^{-1}, respectively) followed by the two mixtures (25% barley 75% vetch) and then (75% barley 25% vetch). Strydhorst et al. (2008) noted that there were differences in crud protein yield amongst faba bean- barley, lupin- barley, pea barley intercrops and sole barley.

Crude fiber (CF): Mature plants usually contained high CF than young plants; seasonal variation affects the crude fiber content (Azim et al., 1989). Annuals plants complete their life cycle within one

season and this might be the reason that annuals quickly end up with high CF.

Table 3. Effect of monocultures and mixtures of barley with fenugreek or vetch at different seeding ratios on crude protean (CP), crud fiber (CF), ether extract (EE), ash and nitrogen free extracts (NFE) contents and yields t.ha^{-1}

Mixture	CP	CF	EE	Ash	NFE	CP	CF	EE	Ash	NFE
			%			Yield t. h^{-1}				
100% barley	7.41	25.70	1.19	9.46	56.24	123	427	20	157	935
75%barley+25% fenugreek	9.29	23.48	1.39	10.65	55.19	124	315	19	143	740
50%barley+50% fenugreek	10.54	21.54	1.75	11.98	54.19	123	250	20	139	630
25%barley+75% fenugreek	12.68	20.52	2.20	12.53	52.07	119	193	21	118	489
100% fenugreek	19.16	18.62	2.43	13.03	46.76	167	162	21	113	407
75% barley + 25% vetch	9.33	23.59	1.36	10.31	55.41	131	331	19	145	777
50% barley + 50% vetch	10.19	22.02	1.51	11.80	54.48	124	268	18	144	663
25% barley + 75% vetch	12.41	20.88	2.12	12.48	52.11	132	222	23	133	553
100% vetch	18.37	19.45	2.47	12.74	46.97	185	196	25	128	461
$LSD_{0.05}$	0.38	0.43	0.12	0.30	0.65	8.5	9.3	1.4	5.4	31.1

Means are averaged over three growing seasons (2004/05, 2005/06 and 2006/07).
t. = ton – h = hectare = 10000 m^{-2} = 2.38 feddan

Crude fiber % ranged from 25.70% in barley to 18.62% in fenugreek (Table 3). Grasses generally had great crude fiber content than forbs and shrubs (Holechek et al. 1998). Generally, CF% is significantly differed ($P<0.05$) between mixture and pure stands. Crude fiber yield differed significantly ($P<0.05$) between sole and mixture, the highest CF yields found in sole barley, and mixtures of 75% barley + 25vech, 75% barley + 25% fenugreek, these values were 427, 331and 315 Kg ha^{-1} , respectively. Results in table 3 indicated that Crude fiber yield was higher in the vetch mixture than fenugreek mixture with significant differences in between, however, sole fenugreek had the lowest CF yield (162 Kg ha^{-1}) followed by sole vetch (196 kg ha^{-1}). This maybe due to low CF content in legumes compared with grasses and low yield of fenugreek and vetch compared with barley.

Ether Extract (EE): varied from 2.47% in vetch to 1.19% in barley; significant differences were found between sole fenugreek or vetch and barley while, the differences between fenugreek and vetch were not reached to significant level ($P<0.05$). Generally, EE% increased with increasing the percentage of fenugreek or vetch in the mixture (Table 3). The highest EE yields found in sole vetch, 25% barley + 75 vetch, sole fenugreek, 25% barley + 75% fenugreek, these value were 25, 23, 21 and 21 kg ha^{-1}, respectively. No clear trend were noticed for the EE yield; this refer to the slightly differences among the mixture yields.

Ash content: (Total mineral) play an important role in promoting balanced growth of animals. However, forage ash content was progressively increased with increasing the degree of plant maturity (Azim et al., 1989). The results showed that ash content of sole fenugreek and vetch were significantly and greater than sole barley (Table 3). It varied from 9.46 % in barley to 13.03% in fenugreek. The lowest ash content was recorded in barley, followed by mixtures of barley 75% + vetch 25% and 50% barley + 50%vetch., respectively.

Generally, the ash content was increased with increasing the percentage of forage legumes (fenugreek and vetch) in the mixtures.

The ash yield per hectare was higher for barley monoculture (157 kg h^{-1}) than mixture of 75% barley +25% vetch (145 kg h^{-1}) refer to the high yield of biomass compared with other mixtures and legume monocultures.

Nitrogen free extracts (NFE): In feeds consist from of carbohydrates, sugars, starches and a major portion of materials classed as hemicellulose. Barley as a pure stand had higher NFE value than sole fenugreek or vetch (Table 2). The differences were significant among sole crops and the mixtures in most cases. Barley had the highest value 56.24% and vetch had the lowest ones 46.97% (Table 2).

Table 4. Average gross energy (GE), average percentage of total digestible nutrients (TDN) and nutritive values (NV).

Mixture sowings	TDN	NV	GE	NE
	%		$MJkg^{-1}$	
100% barley	57.58	7.37	17.048	4.037
75%barley+25% fenugreek	56.39	6.07	16.942	3.878
50%barley+50% fenugreek	55.77	5.29	16.822	3.795
25%barley+75% fenugreek	54.23	4.28	16.917	3.589
100% fenugreek	50.08	2.61	17.171	3.034
75% barley + 25% vetch	56.33	6.04	16.999	3.870
50% barley + 50% vetch	55.83	5.48	16.788	3.803
25% barley + 75% vetch	54.70	4.41	16.900	3.652
100% vetch	50.68	2.74	17.205	3.114
Mean	54.621	4.921	16.977	3.641
$LSD_{0.05}$	4.292	1.758	NS	0.520

Means are averaged over three growing seasons (2004/05, 2005/06 and 2006/07).

It was observed that the maximum NFE yield of 935, 777 and 740 kg h^{-1} was attained by sole barley and mixtures of 75% barley+25% vetch and 75%barley+25% fenugreek (Table 3).

Total digestible nutrients percentage (TDN %): is only an approximate measure of the food energy available to the animal after digestion loss (Lofgreen, 1951), i.e. measure of energy requirement of animal and the energy value of feeds. TDN was calculated using legume and non-legume equation according to Abo-El-Naga and El-Shazly (1971). Table 4 shows significant differences between the monoculture and the mixtures; it was ranged between 50.08% (fenugreek) to 57.58% (barley). The highest TDN % was recorded in sole barley and mixtures of 75% barley + 25fenugreek and 75% barley + 25% vetch, these values were 57.58, 56.39 and 56.33% Kg ha^{-1}, respectively (Table 4)

Nutritive value (NV): was ranged between 2.61(sole fenugreek) to 7.37 (sole barley) with significant differences. However, pure stands of fenugreek and vetch NV value were significantly lower than that of all mixtures and barley pure stands (Table 4).

Gross energy (GE MJkg^{-1}): represents the total energy content of feedstuff or diet and it is a process which the feed resource is completely oxidized to carbon dioxide and water. Gross energy was calculated from chemical analysis; it was fluctuated between 17.048 in sole barley to 16.788 MJ kg^{-1} DM in a mixture of 50% barley + 50% vetch but no significant differences were found between the sole and other mixture crops (Table 4).

Net Energy (NE MJkg^{-1}): in the present study NE was ranged between 3.034 MJkg^{-1} and 4.037 MJkg^{-1}. Significant differences were found between NE of barley (4.037 MJkg^{-1}) and fenugreek (3.034 MJkg^{-1}) and vetch (3.114 MJkg^{-1}), while, no significant differences were found among sole fenugreek and sole vetch, as well as between different mixtures and monocultures plants.

Conclusion

According to the obtained data, the best results in terms of herbage and dry yields were taken from sole barley then followed by mixture of 25% vetch + 75% barley, 75% fenugreek + 25% barley, 50% vetch + 50% barley then followed by 50% fenugreek + 50% barley mixtures. Herbage and dry yield of mixtures were increased with decreasing the proportion of vetch. The highest herbage and dry matter yield per unit area, is a haired by using mixture of 75% barley + 25% vetch or barley pure stands. This is because that barley has the highest value of CF yield, ash yield; NFE yield; TDN, NV and NE; while, fenugreek or vetch has the highest value of CP yield, EE yield and GE.

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تقييم مخاليط الشعير والحلبة و الغرمبوش تحت الظروف المطرية بالساحل الشمالى الغربى لمصر

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تزرع مخاليط الشعير ومحاصيل العلف الشتوية لانتاج الاعلاف على نطاق واسع فى المناطق المطرية وشبه القاحلة بحوض البحر الابيض المتوسط . اقيمت تجربة حقلية لمدة ثلاثة مواسم شتوية (2005/2004 – 2006/2005 – 2007/2006) بمنطقة رأس الحكمة بالساحل الشمالى الغربى لجمهورية مصر العربية وذلك بزراعة الشعير مع الحلبة اوالشعير مع الغرمبوش فى ثلاثة معدلات للخلط (25:75 – 50:50 – 75:25) وكذلك الزراعة المنفردة لكل من النباتات محل الدراسة (الشعير والحلبة والغرمبوش) بهدف دراسة تاثير مكون المخلوط ونسبته على المحصول وجودة العلف . وقد حققت زراعة الشعير منفرداً وكذلك الشعير مع الغرمبوش و الشعير مع الحلبة بنسبة خلط 25:75 على الترتيب أعلى محصول علفى مقارنة مع باقى المخاليط وكذلك مع الزراعة المنفردة للحلبة والغرمبوش. لم يتخطى اى من المخاليط محل الدراسة نسبة مكافئ الارض (LER) للزراعة المنفردة للشعير او الحلبة او الغرمبوش . وقد اظهرت النتائج ان اعلى نسبة بروتين كانت عند زراعة الحلبة والغرمبوش منفرديا. اما أعلى قيمة غذائية (NV) ومجموع مواد مهضومة (TDN) وطاقة صافية (NE) تحققت من زراعة الشعير المنفرد ، بينما لم يكون هناك فروق معنوية لاى من المخاليط اوالزراعة المنفردة بالنسبة للطاقة الكلية (GE) .