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STRATEGY OPTIONS TO IMPROVE GROSS MARGIN IN MIXED CROP-LIVESTOCK FARMING SYSTEM IN SOHAG GOVERNORATE, EGYPT

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SUMMARY

The objectives of this study were to describe the mixed crop-livestock production system among small farms in Sohag governorate, South Egypt and to investigate options for its improvement. Three districts were randomly selected out of the eleven districts of the governorate, Jirjah, Sohag and Akhmim. Data on 420 farmers (35 farmers within 4 villages within 3 districts) were collected during 2004-2005. A linear programming LP model with four scenarios was tested to maximize gross margin (GM), the first assumes free choice among all studied variables of crops and livestock (base run (LP1)). While, the second scenario (LP2) had a constraint on cropping pattern to meet farmer's needs of basic food and feed crops and assuming free choice of number of each different animal types (local cattle, crossbred cattle buffalo, sheep and goat). The third scenario (LP3) assumed free choice of cropping pattern and had a constraint to the number of each studied animal type. The fourth scenario (LP4) had the cultivated area distributed equally on different crops and had a constraint to the number of each animal types. Results suggested that, as compared to actual situation, GM was improved by about 48% to 105% in LP1; 19% to 67% in LP2 and 30% to 72% in LP3 and -0.3% to 33% in LP4 in different distracts. As compared to LP1, GM in LP2 and LP3 decreased by about 29 to 38% and 18% to 33%, respectively. GM in LP3 increased by about 5% to 11% as compared to LP2. In addition, GM in LP4 decreased by about 48% to 72% as compared to LP1. It was concluded that small ruminants were more profitable than large ruminants within crop-livestock production system in Sohag governorate. Both land and available cash resources are limiting constrains for LP model but not labor.

Keywords: Linear programming, Gross margin, Sheep, Goat

INTRODUCTION

In many developing countries, the distribution of livestock ownership suggests that livestock farming is especially important for the poor and landless who have insufficient land to support their families. Egypt is one of the most densely populated countries in the Mediterranean, African and Near East region. Located in the more

arid region of the world, the arable land does not exceed 3.4 millions hectares and more than 95% of crop lands are irrigated with the Nile. The average land size does not exceed 1 ha per farm and the number of farms increased from 1 to 3.7 millions from 1950 to 2000. Sohag governorate, located in South Egypt, that encompasses Aswan, Sohag, Qena, Red Sea and Luxor City. Agriculture is the governorate's basic economic activity where cultivated areas cover 315.5 thousand feddans (1 feddan = 4200 sq m) (ICLDU, 2006). The main production system in Sohag is the mixed crop-livestock production. This work aimed at investigating different options of input combinations to improve crop-small ruminant production subsystem in Sohag within the crop-livestock production.

MATERIALS AND METHODS

***Data Collection and Coefficients*:**

Sohag governorate is in the middle of the South Egypt between 26" 36" 26 N latitudes and 31" 47" 80 E longitudes. The governorate comprises eight districts on the western side of the River Nile and three districts on the eastern side (Figure 1). Three districts were randomly selected for this study, Jirjah, Sohag (in the western side of the River Nile) and Akhmim (in the eastern side of the River Nile). Within each district four villages were randomly selected and thirty five farmers within each village were randomly chosen (total number of farmers = 420).

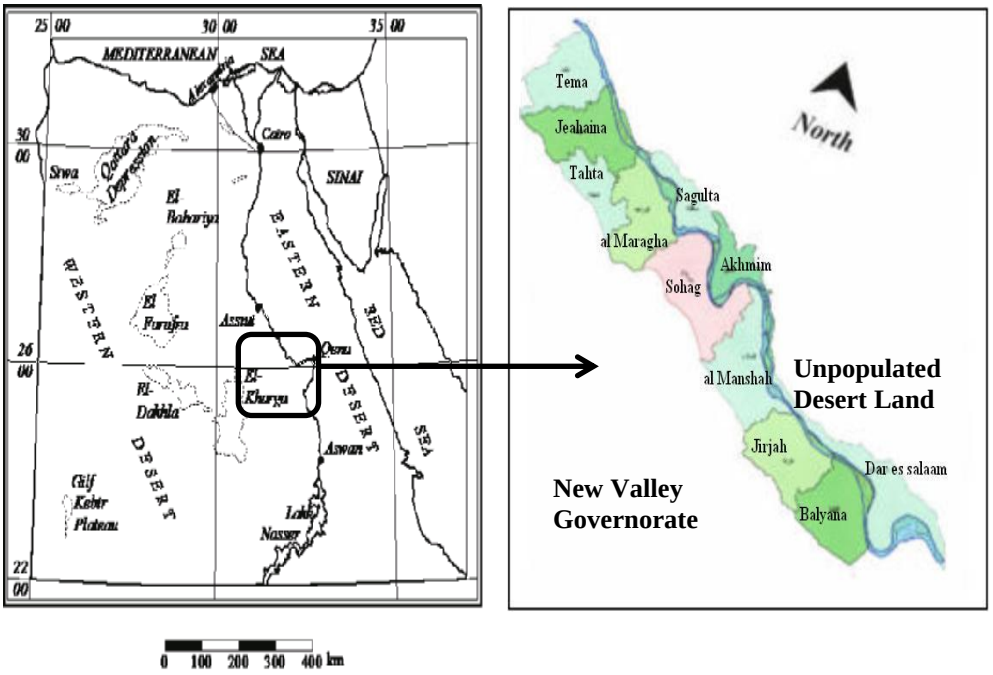

Figure 1. Map of Egypt and map of Sohag governorate

Data were collected during 13 months from August 2004 to September 2005.

Information was collected through a field survey using structured questionnaire to identify available resources (Table 1), as follows:

- general information on village, district and date of visit;
- socio-economic features of the farmer and his family;
- family members contribution in cultivation and animal production activities;
- farm size and main field crops;
- flock and herd size for different livestock species; and
- management systems of small ruminant flocks/herd.

Variables included in this study were area cultivated each with wheat (*Triticum Sp*.), berseem (*Trifolium alexandrinum*) and faba bean (*Vicia faba*) as winter crops and maize (*Zea mays*), sorghum (*Sorghum bicolor*), millet (*Pennisetum typhoides*) and darawa (fodder maize) (*Zea mays*) as summer crops. Livestock variables were number of local cattle, crossbred cattle, buffalo, sheep, goats and animal units (AU).

Table 1. Description of available resources in the three different studied districts

Item	Akhmim	Jirjah	Sohag
Sample size	140	140	140
Resources			
Average farm size (feddan)*	1.58	1.59	1.87
Average family size (person)	6.12	4.99	6.36
Annual labor used (p/d)			
Winter	516	417	511
Summer	516	417	511
Cropping pattern (feddan)			
Winter Wheat	0.66	0.84	0.93
Berseem	0.85	0.62	0.85
Faba bean	0.07	0.12	0.09
Summer Maize	0.47	0.50	0.64
Sorghum	0.26	0.51	0.42
Millet	0.71	0.13	0.72
Green fodder (darawa)	0.14	0.12	0.09
Livestock			
Local cattle (AU)	0.36	0.34	0.31
Crossbred cattle (AU)	0.0	0.15	0.11
Buffalo (AU)	1.13	1.04	1.01
Sheep (EE)	14.32	10.97	12.70
Goat (DE)	6.15	5.45	6.41
Total (AU)	4.97	4.32	4.68

* feddan = 4200 m^2, p/d = person per day, AU= animal unit, EE = ewe equivalent = 1.89 lamb, DE = doe equivalent 1.89 kid. Animal unit = 5.9 ewe or doe, AU = 11.1 lamb or kid, AU = 3.3 calves AU = 0.89 buffalo and AU = 1 mature cattle (Barnard and Nix, 1993)

Mathematical Linear Programming (LP) Model.

Studies by Alsheikh *et al*. (2002) and Alsheikh *et al*. (2007) showed that land and livestock are the most determinant variables in crop-livestock production system in Egypt. One LP model was used with four modified scenarios tested utilizing land, livestock, labor and amount of available cash resources (ACR) using General

Algebra Modeling Systems (GAMS, 2000). Modification was tried only on land and livestock constrains. While, labor and ACR constancies are the same in the different four studies scenarios.

Base Run Scenario (LP1). Assuming free choice of crop and livestock studied variables to maximize the gross margin (GM), where,

Objective function Maximize (GM) = $\sum_{i=1}^{12} a_i x_i$,

where,

a_i is GM for each variable of x_i , x_i are area in feddans cultivated with wheat (x_1), berseem (x_2), faba bean (x_3), maize (x_4), sorghum (x_5), millet (x_6) and green fodder (x_7) (darawa), number of local cattle (x_8), crossbred cattle (x_9), buffalo (x_{10}), sheep (x_{11}) and goat (x_{12}).

with the constraints:

Land: Winter $x_1+x_2+x_3$ = average farm size (feddan)

Summer $x_4+x_5+x_6+x_7$ = average farm size (feddan)

Livestock: $x_8+ x_9+ x_{10}+ x_{11}+ x_{12} \leq$ livestock respective numbers,

Labor: $\sum_{i=j=1}^{12} c_j x_i \leq b$,

where,

c_j is labor (person per day) requirement,

b is the total family labor and x_i as before;

and available cash resources (ACR), $\sum_{i=j=1}^{12} d_j x_i \leq m$,

where,

d_j is variable cost for each variable,

m is ACR, and x_i as before.

Diversity of cultivated crops scenario (LP2):

In this scenario the cultivated area was distributed equally on different crops and assuming free choice of livestock species to maximize GM, where the

Objective function was Maximize (GM) = $\sum_{i=1}^{12} a_i x_i$,

where,

a_i and x_i are as defined before,

with constraints:

Land: Winter x_1 = 1/3 farm size

x_2 = 1/3 farm size

x_3 = 1/3 farm size

$x_1+x_2+x_3 \leq$ average farm size

Summer x_4 = 1/4 farm size

x_5 = 1/4 farm size
x_6 = 1/4 farm size
x_7 = 1/4 farm size
$x_4 + x_5 + x_6 + x_7 \leq$ average farm size.

Livestock, labor and ACR are the same as in LP1.

Modified Flock Structure Scenario (LP3):

In this scenario a free choice of cultivated crops was assumed and livestock production was constrained with at least one animal unit (AU) of local cattle, crossbred cattle or buffalo in addition to at least one ewe equivalent (EE) of sheep and doe equivalent (DE) of goat to maximize GM.

Objective function:

$$\text{Maximize (GM)} = \sum_{i=1}^{12} a_i x_i,$$

where,

a_i and x_i are as defined before.

with constraints:

Land: Winter $x_1+x_2+x_3 \leq$ average farm size (feddan)

Summer $x_4+x_5+x_6+x_7 \leq$ average farm size (feddan)

Livestock:

$x_8 \geq 1$ AU of local cattle
$x_9 \geq 1$ AU of cross bred cattle
$x_{10} \geq 1$ AU of buffalo
$x_{11} \geq 1$ ewe equivalent
$x_{12} \geq 1$ doe equivalent

Labor and ACR are the same as LP1.

Real Scenario (LP4):

The constraints of this scenario were designed to simulate the real situation as appearing in the actual situation. In this scenario the cultivated area was distributed equally on different crops while livestock was constrained with at least one animal unit (AU) of local cattle, crossbred cattle or buffalo in addition to at least one ewe equivalent (EE) of sheep and one doe equivalent (DE) of goat to maximize GM.

Objective function:

$$\text{Maximize (GM)} = \sum_{i=1}^{12} a_i x_i,$$

where,

a_i and xi are as defined before.

Constraints:

Land: Winter, x_1 = 1/3 farm size
x_2 = 1/3 farm size
x_3 = 1/3 farm size
$x_1+x_2+x_3 \leq$ average farm size
Summer, x_4 = 1/4 farm size
x_5 = 1/4 farm size
x_6 = 1/4 farm size

x_7 = 1/4 farm size

$x_4+x_5+x_6+x_7 \leq$ average farm size.

Livestock:

$x_8 \geq 1$ AU of local cattle

$x_9 \geq 1$ AU of cross bred cattle

$x_{10} \geq 1$ AU of buffalo

$x_{11} \geq 1$ ewe equivalent

$x_{12} \geq 1$ doe equivalent

Labor and ACR are the same as LP1.

RESULTS AND DISCUSSION

Financial Analysis:

Table 2 shows GM for each crop per feddan and livestock activity calculated from collected data. The GM of all the studied variables was positive in the three districts except for local cattle and buffalo in Jirjah, LE -228 and LE -141, respectively. This could be due to that farmers in Jirjah cultivated only 0.25 feddan of green fodder (darawa plus millet) in summer (Table 1). This cultivated area is too small for feeding animals where farmers kept an average of 4.32 AU (Table 1), thus farmers depended on concentrate feed which has a high monetary value.

Table 2. Gross output (GO), variable cost (VC), gross margin (GM) and available cash resources (ACR) in Egyptian pound (LE) per feddan

Item	Akhmim			Jirjah			Sohag		
	GO	VC	GM	GO	VC	GM	GO	VC	GM
Winter crops									
Wheat	3581	881	2700	3485	851	2635	3518	852	2666
Berseem	3171	272	2899	3082	264	2819	3075	270	2805
Faba bean	2210	531	1679	2226	559	1667	2093	521	1572
Summer crops									
Maize	2527	1045	1482	2677	1051	1626	2540	1052	1488
Sorghum	2232	900	1332	2234	886	1348	2249	902	1347
Millet	3724	565	3159	3836	546	3291	3527	553	2974
Darawa	3735	544	3141	3892	574	3319	2979	524	2455
Livestock activities									
Local cattle	1650	1464	186	1252	1467	-228	1602	1388	213
Cross- cattle				1968	1837	132	1883	1479	404
Buffalo cow	1298	1081	216	976	1095	-141	1162	979	183
Adult ewe	166	91	75	187	132	55	183	110	73
Adult doe	103	71	32	91	68	24	87	62	25
ACR		7406			9335			8691	

Values rounded to the nearest integer.

Base Run (LP1):

The results of LP1 for the three districts are shown in Table 3. In order that farmers get the maximum GM, the output suggests that, they should go for sheep and cultivate all their farm area with berseem in winter, in the three districts. While in summer, they should cultivate all area with green fodder (darawa), in Akhmim and Jirjah, and with millet in Sohag. Also, they should keep 67, 60 and 65 ewe

equivalents in Akhmim, Jirjah and Sohag, respectively, with no other livestock. Moreover, if farmers decided to cultivate wheat and faba bean in winter (Table 3) in Akhmim their production cost would reduce by LE 700 and LE 1433 per feddan, respectively. While, in summer cultivating maize, sorghum and millet would reduce production cost by LE 2121, LE 2152 and LE 49 per feddan, respectively. GM in LP1 was higher than that in the actual situation by about 51%, 105% and 48%, in Akhmim, Jirjah and Sohag, respectively. This improvement of GM is due to directing the available cash resources to variables with the highest GM. Return per feddan in LP1 was higher than that in actual situation by about 51%, 114% and 48% in Akhmim, Jirjah and Sohag, respectively. These results have the same trend as the results obtained by Alsheikh *et al*. (2002 and 2007). The contribution of livestock to GM in LP1 came from sheep only. This could be due to that sheep have low variable cost. Also, goats have the lowest opportunity cost in the three studied districts. These results agree with Younis (1998) in that small ruminants could be more profitable than large ruminants in crop-livestock production system in South Egypt.

Diversity of cultivated crops (LP2):

This scenario was designed to avert market risk due to cultivating only one type of crop and to satisfy farmers basic crop needs. The optimal LP2 for Akhmim, Jirjah and Sohag is shown in Table 3. To get maximum GM for farmers they should raise 58, 54 and 56 ewe equivalents in the three districts, respectively plus the restricted cultivated area within each district. In this scenario, the land constraint led to increased both GM and RPF by about 22%, 67% and 19% than actual situation and to decreased GM and RPF by about 29%, 40% and 29% than the base run (LP1) in Akhmim, Jirjah and Sohag, respectively. These results could be due to farmers by transferring their ACR to the cultivation of crops to satisfy their needs, they have less money to keep sheep. These results support the finding of Bhatia and Ganwar (1981) that, farmers have different type of thinking other than just maximizing their farm income. Also, Abdulkadri and Ajibefun (1998) suggested that farmers could have objective(s) other than profit maximization like family consumption and diversification of crops to avert market risk.

Modified flock structure (LP3):

In this scenario the LP programming was modified as free choice of cropping pattern in winter and summer, while livestock was constrained with at least one animal unit from local cattle, crossbred cattle and buffalo plus one ewe equivalent and one doe equivalent to maximize GM. The optimal LP3 for the three districts are shown in Table 3. The cropping pattern in LP3 was the same as suggested from LP1 along with raising one AU of local cattle, one AU of buffalo, 31 EE and 10 DE in Akhmim. While in Jirjah farmers have to raise one AU each from local cattle, crossbred cattle and buffalo plus 22 EE and 10 DE to get maximum GM. Also, in Sohag the farmers should keep the same AU each from large ruminants plus 24 EE and 10 DE. These results led GM in LP3 being higher than that in actual situation by about 31%, 72% and 30%, less than the value obtained in LP1 by 20%, 33% and 18% and higher than the value obtained in LP2 by 9%, 5% and 11% in Akhmim, Jirjah and Sohag, respectively. This is due to the constraints on raising livestock which has less GM and keeping less number of small ruminants.

The real scenario (LP4):

The optimal LP4 for the three districts are shown in Table 3. When modifying the LP model constraints to simulate the real situation, the output shows that farmer should have one AU each of local cattle, crossbred cattle, buffalo and 10 doe equivalents in Akhmim Jirjah and Sohag, respectively, plus keeping 22, 16 and 16 ewe equivalents to get maximum GM. Constraining cultivated crops and keeping all animal genotypes led to GM to be less than the value obtained in LP1 by 49%, 72% and 48% in Akhmim, Jirjah and Sohag, respectively. While in Akhmim and Jirjah GM was higher than that in actual situation by about 2% and 33% and in Sohag was less than that in actual situation by about 0.33%, respectively. Moreover, the return per feddan was changing by 3%, 25% and -0.03% in Akhmi, Jirjah, and Sohag, respectively compared with actual situation. This could be due to the land constrain, which led to directing the available cash resources to cultivation and raising large ruminants, which have less GM than small ruminants thus allowing less available cash resources to keep ewe equivalents.

CONCLUSIONS

The present linear programming model with the four scenarios showed that sheep followed by goats are more profitable than large ruminants within the crop-livestock production system in South Egypt. Land, livestock and available cash resources are limiting constrains but not labor.

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سيناريوهات بديله لتحسين هامش الربح فى منظومة مزارع المحاصيل- الحيوانات المزرعية المختلطة في محافظة سوهاج، مصر

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تهدف هذه الدراسة إلى وصف المنظومة المختلطة من المحاصيل – الحيوانات المزرعيه فى المزارع الصغيرة في محافظة سوهاج في صعيد مصرواقتراح بدائل لتحسينها. أختير ثلاثة مراكز عشوئيا من أحد عشر مركزاً تابعة للمحافظة. جمعت البيانات من ٤٢٠ مزارع (٣٥ مزارع في ٤ قرى في ٣ مراكز) خلال عامي ٢٠٠٤ و٢٠٠٥. استخدم نموذج واحد للبرمجة الخطية (LP) لمعظمة العائد الكلى لإنتاجية المحاصيل والحيوانات المزرعية فى المزارع الصغيرة. وقد اقترحت أربعة سيناريوهات لذلك النموذج. السيناريو الأول، يفترض حرية الاختيار بين جميع المتغيرات محل الدراسة (LP1)، في حين، كان السيناريو الثاني (LP2) يفرض قيدا على نمط الزراعة لتلبية احتياجات المزارعين من المحاصيل الغذائية و العلفية على أن يترك الحرية للبرنامج في اختيار المتغيرات الممثلة للحيوانات المزرعية. السيناريو الثالث (LP3) يترك الحرية للبرنامج للاختيار بين متغيرات المحاصيل محل الدراسة ووضع قيدا على العدد المحتفظ به فى المزرعة من الحيوانات المزرعية المختلفة. بينما فى السيناريو الرابع (LP4) كانت فيه المساحة المنزرعة موزعة بالتساوي على المحاصيل المختلفة محل الدراسة كما وضع قيدا على العدد المحتفظ به في المزرعة من الحيوانات المزرعية لتجنب الحل الناتج من LP1 . وقد أوضحت النتائج أنه بالمقارنة مع الوضع الفعلى، هامش الربح تحسن ما بين حوالى ٤٨% الى ١٠٥٪ في LP1 ، ١٩٪ الى ٦٧٪ في LP2 و٣٠٪ الى ٧٢٪ في LP3 و- ٠.٣% الى ٣٣% فى LP4 فى المراكز المختلفة. وبالمقارنه مع LP1 هامش الربح فى كلا من LP2 و LP3 انخفض بحوالى ٢٩% الى ٣٨% و ١٨% الى ٣٣% على الترتيب. هامش الربح فى LP3 زاد بحوالى ٥% الى ١١% بالمقارنه مع LP2. بالاضافة الى ان هامش الربح فى LP4 انخفض بحوالى ٤٨% الى ٧٢% بالمقارنة مع LP1. ويمكن استخلاص ان المجترات الصغيرة كانت أكثر ربحية من المجترات الكبيرة فى منظومة انتاج المحاصيل- الحيوانات المزرعية فى محافظة سوهاج. تعتبر كل من الأرض ورأس المال المتاح من العوامل المحددة لنموذج البرمجة الخطية بينما لم تكن العمالة كذلك

Table 3. Linear programming LP1, LP2, LP3 and LP4 output of the three studies districts, diversity of cultivated crops

Item	Akhmim								Jirjah								Sohag							
	AS	LP1	OC	LP2	OC	LP3	OC	LP4	AS	LP1	OC	LP2	OC	LP3	OC	LP4	AS	LP1	OC	LP2	OC	LP3	OC	LP4
Cropping pattern (feddan)																								
Winter																								
Wheat	0.66	0	700	0.53	0	0	700	0.53	0.84	0	427	0.84	0.53	0	428	0.53	0.93	0	524	0.63	0	0	524	0.62
Berseem	0.85	1.58	0	0.53	0	1.58	0	0.53	0.62	1.59	0	0.62	0.53	1.59	0	0.53	0.85	1.87	0	0.63	0	1.87	0	0.62
Faba bean	0.07	0	1433	0.53	0	0	1433	0.53	0.12	0	1273	0.12	0.53	0	1273	0.53	0.09	0	1399	0.63	0	0	1399	0.62
Summer																								
:Maize	0.47	0	2121	0.4	0	0	2121	0.4	0.50	0	1890	0.50	0.4	0	1890	0.4	0.64	0	1817	0.47	0	0	1817	0.46
Sorghum	0.26	0	2152	0.4	0	0	2152	0.4	0.51	0	2100	0.51	0.4	0	2100	0.4	0.42	0	1858	0.47	0	0	1858	0.46
Millet	0.71	0	49	0.4	0	0	49	0.4	0.13	0	16	0.13	0.4	0	16	0.4	0.72	1.87	0	0.47	0	1.87	0	0.46
Darawa	0.14	1.58	0	0.4	0	1.58	0	0.4	0.12	1.59	0	0.12	0.4	1.59	0	0.4	0.09	0	499	0.47	0	0	499	0.46
Livestock																								
L-cattle (AU)	0.36	0	1020	0	1202	1	0	1	0.34	0	834	0.34	0	1	0	1	0.31	0	707	0	707	1	0	1
C-cattle (AU)	0	0	0	0	0	0	0	0	0.15	0	627	0.15	0	1	0	1	0.11	0	577	0	589	1	0	1
Buffalo (AU)	1.13	0	673	0	673	1	0	1	1.04	0	594	1.04	0	1	0	1	1.01	0	466	0	466	1	0	1
Sheep (EE)	14.3	67	0	58	0	31	0	22	10.9	60	0	10.9	54	22	0	16	12.70	65	0	56	0	24	0	16
Goat (DE)	6.15	0	26	0	26	10	0	10	5.45	0	4	5.45		10	0	10	6.41	0	16	0	16	10	0	10
Land (feddan)																								
Winter	1.58	1.58	0	1.58	0	1.58	0	1.58	1.59	1.59	0	1.59	0	1.59	0	1.59	1.87	1.87	0	1.87	0	1.87	0	1.87
Summer	1.58	1.58	0	1.58	0	1.58	0	1.58	1.59	1.59	0	1.59	0	1.59	0	1.59	1.87	1.87	0	1.87	0	1.87	0	1.87
Labor (p/d)																								
Winter	516	516	0	516	0	516	0	516	417	417	0	417	0	417	0	417	511	511	0	511	0	511	0	511
Summer	516	516	0	516	0	516	0	516	417	714	0	714	0	417	0	417	511	511	0	511	0	511	0	511
ACR (LE /F)	7406								9335								8691							
GM (LE)	9674	14663		11884		12703		9924	6348	13068		10616		10968		8494	10457	15553		12456		13640		10422

RPF (LE)	6122	9280	7521	6122	6281	3992	8230	6676	6898	5342	5591	8317	6661	7294	5573

AS = actual situation; OC = opportunity cost; p/d = person per day; ACR = available cash resources; GM = gross margin; RPF = return per feddan.