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Impact of complementary irrigation in grain production for the northern zone of Buenos Aires considering the climatic risk.

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Abstract:

The purpose of this report is to provide an evaluation of the impact of supplementary irrigation in grain production in the northern area of the Province Buenos Aires, Argentina within the framework of risk analysis and with emphasis on risk related to weather. An economic analysis of a productive model in the mentioned area, characterized by fertile soils and considering a farm of 400 hectares destined integrally to the production of grains is carefully developed. This analysis clearly shows that the main impact of supplementary irrigation is associated with the reduction of variability in yields and with the increase of expected farm income and net revenue. The rate of return on investment on irrigated agriculture more than doubles the one related to rainfed agriculture.

Acknowledgment: My name is Anibal Leandro Nuñez, argentinean economist finishing the studies of magister in agrarian economy (Universidad de Buenos Aires). I am currently working in the Ministry of Agro-industry. The work was done in conjunction with Dr. Raul Fiorentino (Ph.D University of California in Davis), who also works in the Ministry of Agro-industry. The purpose of this report is to provide an evaluation of the impact of supplementary irrigation in grain production in the northern area of the Province Buenos Aires, Argentina within the framework of risk analysis and with emphasis on risk related to weather.

JEL Codes: Q15, Q15

#1244



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ABSTRACT

The purpose of this report is to provide an evaluation of the impact of supplementary irrigation in grain production in the northern area of the Province Buenos Aires, Argentina within the framework of risk analysis and with emphasis on risk related to weather. An economic analysis of a productive model in the mentioned area, characterized by fertile soils and considering a farm of 400 hectares destined integrally to the production of grains is carefully developed. This analysis clearly shows that the main impact of supplementary irrigation is associated with the reduction of variability in yields and with the increase of expected farm income and net revenue. The rate of return on investment on irrigated agriculture more than doubles the one related to rainfed agriculture.

Key words: complementary irrigation - core zone – income stability – yield stability.

ORIENTATIONAL THEMATIC CLASSIFICATION:

- Added value based on primary production
- Organizational models of production, agrarian structure and rurality.

1. Foundation

Within the framework of the Argentine National Irrigation Program (Programa Nacional de Riego) several working papers have been prepared, which provide economic evaluations of the impact of complementary irrigation in grain production in the fertile Pampean Region of Argentina (Programa Nacional de Riego, March 2017, April 2017, August 2017).

In these analyses, estimates of economic efficiency for complementary irrigation projects in "models" of irrigated farms with 400 ha of usable area are developed. Two alternative crop combinations are considered in each evaluation : (a) a biennial sequence corn-wheat- late soybean-wheat and (b) al also biennial sequence of wheat-late soybean-wheat-late soybean. Both production sequences are widely used in most fertile lands in the Pampas.

The information used for these previous analyses includes average or "expected" crop yields, both for rainfed and for irrigated production. Thus, information excludes any consideration related to inter-annual variability of yields. As it is usual in most production schemes of the Pampean Region, variability of yields is high in rainfed agriculture (due to the erratic pattern of rainfall) and low in irrigated agriculture.

It is concluded in these works that (a) the incorporation of complementary irrigation in the northern zone of Buenos Aires increases the expected values of average yield and gross margin for each crop and also for the crop combinations; (b) however, economic estimates show that switching agriculture from rainfed production to irrigated production is not economically convenient (low values for IRR and PV of net income).

As indicated previously, statistical information available indicates that grain yields under rainfed agriculture are very variable when considering successive crop cycles (for details on this topic see Section 3 of this report). Thus, the economic impact of supplementary irrigation on grain crops in Argentina (particularly corn, soybean and wheat) presents two dimensions of interest: (a) the relevant increase in the average yields of these crops through the incorporation of irrigation; (b) the reduction of the variability of yields when switching from rainfed to irrigated production.

The purpose of this report is to assess the economic impact of complementary irrigation within the framework of risk analysis, and more specifically taking climatic risk under consideration. A farm model with 400 hectares of net farm land and located in the Northern Region of Buenos Aires is economically analyzed.

2. Hypothesis and objectives.

The hypothesis of this paper is that *the differential returns provided by the investment in grain irrigation are mainly explained by the stabilization of yields rather than by their increase. In turn, the economic evaluation of the economic impact of irrigation without including climate risk underestimates the levels of return on investment in the productions involved.*

This is due to the fact that the increase in the internal rate of return when rainfed agriculture is substituted by irrigated agriculture is related to two dimensions of equal interest: (a) increase in yields with respect to a reference value (average or expected value of yields under rainfed agriculture); (b) increase in yields with respect to actual values, which are highly variable. Considering the two factors, the impact on return on investment is important.

This hypothesis provides a clear justification for the objective of this work: to evaluate the impact of complementary irrigation in the framework of risk analysis, with emphasis on climate risk.

3. Variability of yields and climate impact.

The analysis of yields of the three main crops under consideration for the 2001 to 2015 campaigns reveals great variability. Table 1 shows that the average maize yields for the 2001 – 2015 period are around 8400 kg / ha, those of early soybean around 3480 kg / ha, those of late soybean around 1914 kg / ha and those for wheat around 3965 kg / ha. The standard deviations of yields are: 1381 kg/ha for corn, 527 kg/ha for early soybean, 290 kg/ ha for late soybean and 954 kg / ha for wheat. Therefore, the relative values of variability are of the order of 16% for corn, 15% for early soybean and late soybean and 24% in wheat.

Table 1: Average yields of corn, soybeans and wheat under rainfed conditions in the northern area of Buenos Aires (Campaigns 2001/2 to 2015/16).

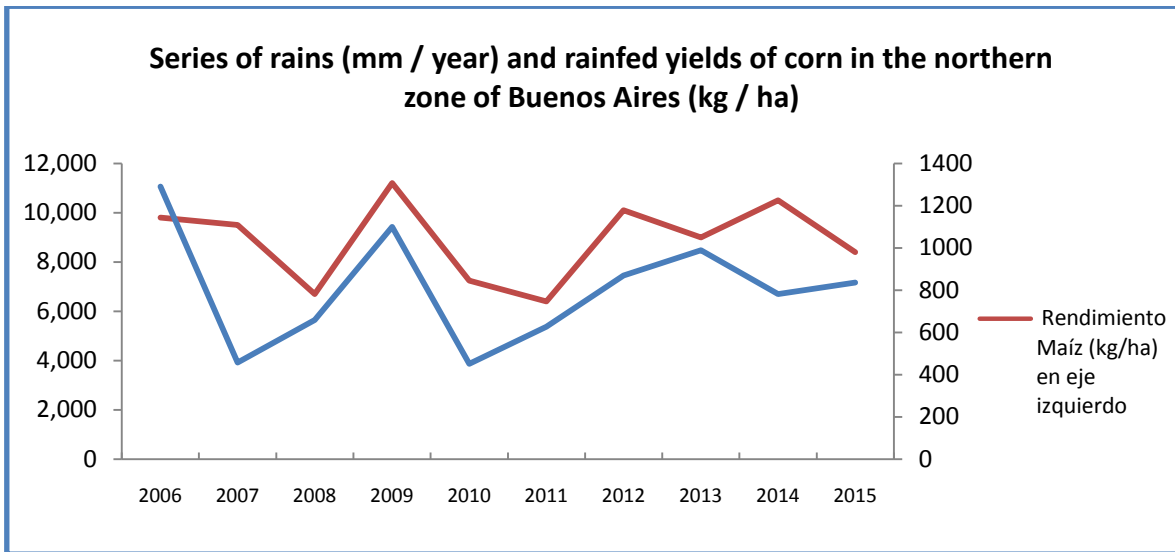
Year	Northern Area of Buenos Aires			
	Corn (kg/ha)	Early soybean (Kg/ha)	Late soybean (Kg/ha)	Wheat (Kg/ha)
2001	6.521	2.807	1.544	2.160
2002	7.938	3.217	1.769	2.079
2003	8.411	3.092	1.701	3.024
2004	8.694	3.210	1.766	3.213
2005	7.088	3.405	1.873	3.497
2006	9.261	3.342	1.838	3.780
2008	8.978	3.497	1.924	4.347
2008	6.332	2.005	1.103	2.268
2009	10.584	3.660	2.013	5.099
2010	6.847	3.585	1.972	4.684
2011	6.048	3.178	1.748	4.631
2012	9.545	3.506	1.928	2.930
2013	8.505	3.789	2.084	4.253
2014	9.923	4.318	2.375	3.686
2015	7.938	3.915	2.153	3.969

Source: Estimates based on detailed data provided by MINAGRO, 2017.

Several works carried out in the last decade indicate that: (a) the two most relevant climatic risk factors in the Argentine Pampean Region are associated, in grain production, to the availability of humidity ("water stress") and to the existence of extreme temperatures in relevant phenological phases ("thermal stress"); (b) in an important part of the Pampean Region, the impact of water stress is the most relevant and is centrally linked to periods of severe drought. See for references Fernández Long and Others (AgriScientia, Córdoba, June 2011) and Satorre and others (AAPRESID - Innovation Network, Buenos Aires, 2016).

Graphic information about corn yields in the 2006– 2015 period for the Northern Area of the Province of Buenos Aires is shown in Figure 1. Analysis of this figure reveals that in rainfed agriculture corn yields are strongly related to rainfall. The value of the Correlation Coefficient indicates that 77% of the variability of yields is explained by rainfall. Information about the remaining grain crops (soybean, wheat), with high but somewhat lower levels of correlation between rainfall and yields, is omitted for space considerations.

Figure 1: Rains and yields of rainfed corn in the North of Buenos Aires.



Source: Estimates based on crude data reports by Agricultural Estimates of MINAGRO (2017).

4. The farm model and its activities.

The northern region of the Province of Buenos Aires (Departments of Pergamino and Arrecifes) has deep, dark soils with high natural fertility, content of organic matter and capacity for water accumulation. The dominance of fertile types (mostly of the Order Molisols can be ascertained by taking a look at Figure 2.

Figure 2. Map of soils in the Departamentos of Pergamino and Arrecifes, Province of Buenos Aires.



Source: Upon information provided by Geo-INTA Viewer (2017).

The farm model considered in this report incorporates, for irrigation purposes, two center pivot equipments. Technical details about of these equipments are described in *MINAGRO (January 2017)*. The investment value of this equipment is in the order of USD 948 thousand, equivalent to a unit value of USD 2370 per hectare.

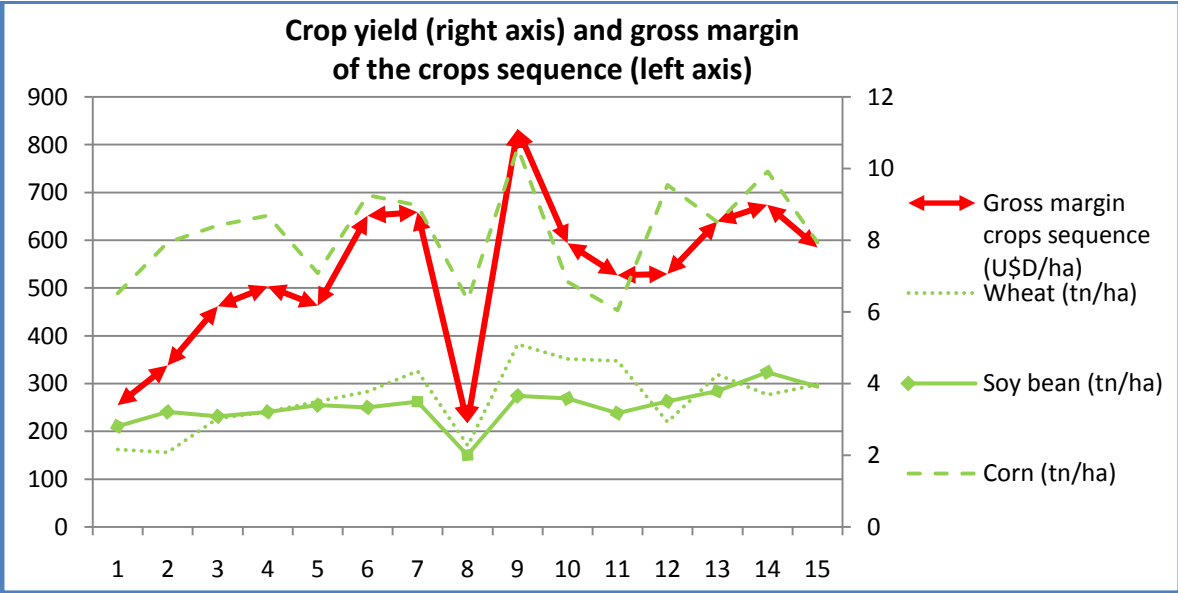
5. Gross margins for individual crops and for the crop sequence under rainfed and irrigated conditions.

a. Rainfed grain production

The high variability of yields affects gross margins of individual crops and of the biannual sequence. It is expected gross margins variabilities (both for each individual crop and for the rotation) be larger than those observed in yields. This is due to the fact that the farmer incurs in full costs to implement the adequate technology without the possibilities of anticipating productive results. If these results are poor, a large part of the incurred costs will not be associated with higher production and higher revenues.

Figure 3 shows both variability in crop yields and in gross margins for rainfed grain crops. Values of yields for three crops (wheat, corn and late soybean) are shown in that figure for a period of 15 years (2001 - 2015). Figure 3 also shows the gross margin of the two years sequence (corn-wheat-late soybean-wheat). The detailed calculation of gross margins is presented in Annex 3 of this report.

Figure 3: Income and gross margins in rainfed and irrigated production



Source: estimates based upon data on prices and yields as supplied by MINAGRO (August 2016).

It can be observed that the gross margin of the sequence under rainfed conditions fluctuates between the wide gap of 217 U\$D / ha and 833 U\$D / ha, with the average value of the gross margin of 529 U\$D / ha. The standard deviation of the gross margin is about U\$D 165/ha and its relative deviation 31%.

A quick comparison allows to appreciate that the relative variability of gross margin is approximately twice the variability of corn yields (16%) and of soybean yields. It's also (15%) and 7% higher than the relative variability of wheat yields (24%). Therefore, under climatic risk conditions the variability of the gross margin of the crops sequence is considerably higher than the variability of yields.

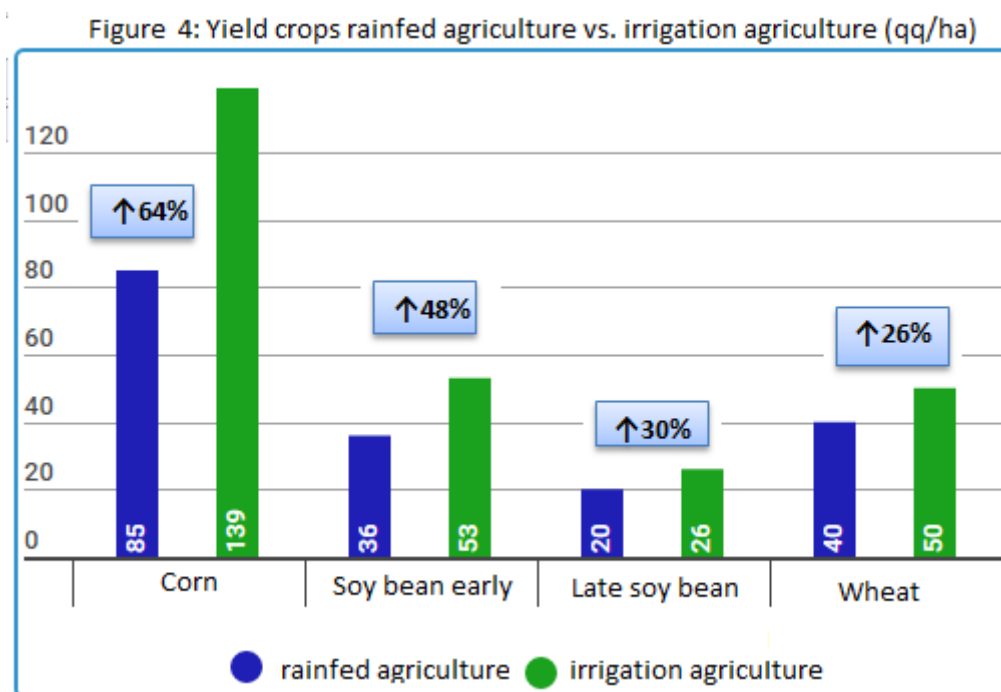
5.b Irrigated grain production

Table 2 shows the expected yield of each of the crops under irrigated agriculture and figure 4 shows the increases in the expected yields of each crop when rainfed agriculture is substitute by irrigated grain production.

Table 2: Yields under irrigated agriculture.

Yields of crops under irrigated agriculture				
Crop	Corn	Soy bean	Late soy bean	Wheat
Yield	13,9	5,3	2,6	5,0

Source: own elaboration upon to the magazine *Márgenes Agropecuarios* (2016) and FAO / PROSAP 2015.



Source: Estimates supplied by the Monthly Review *Márgenes Agropecuarios* (2016) and by reports of FAO / PROSAP 2015.

Figure 4 shows that irrigation generates a greater impact on corn (64% increase in yield) followed by early soybean (48% increase) and late soybean (30% increase). The impact of irrigation on wheat yield is only 26%. Although, wheat is the crop that shows less impact

on the increase of yields with the implementation of complementary irrigation, it is the crop that registers better results in terms of a potential reduction of the variability of yields.

Review of the literature on the subject (Cataldo and Cabrini, February 2014; Fernández Long and Others, June 2011) indicates that the supply of irrigation in grains significantly reduces the variability in yields. Based on detailed simulation models, these works show that the variability in yields under irrigation reaches maximum values of 5%. This reference authorizes, in order to facilitate the evaluation of the economic impact of the complementary irrigation, to consider that variability is virtually non-existent, so that we offer a single calculation of the gross margin of the rotation under irrigation.

Table 3 shows that for the biannual sequence the estimated gross margin is US \$ 854 / ha per year. Details for this estimation are shown in Annex 4 of this report.

Table 3: Net income of the sequence Corn-wheat-late soybean-wheat with irrigation.

Net income & gross margin of the sequence	Unity	Corn	Wheat	Late soy bean	Wheat	Sum	Sum/2
Gross income	(USD/ha)	2.039	905	734	905	4.583	2292
Total direct cost	(USD/ha)	1.270	547	511	547	2.875	1438
Gross margin irrigation	(USD/ha)	770	357	223	357	1.708	854
General (fixed) costs	(USD/ha)						221
Net income (USD / ha)							633

Source: own elaboration based on data provided by the Magazine Márgenes Agropecuarios and FAO 2015.

6. Return on investment analysis

In this section, the impact of risk on the return of an investment in irrigation is evaluated considering a project which incorporates the irrigation equipment previously described (section 2 and also Annex 2 of this work) in the hypothetical farm model which was also previously described.

Two alternatives for the economic analysis are considered: a) comparison of gross margins under irrigation with the average or expected gross margins in rainfed production; and b) comparison of gross margins under irrigation with variable margins without irrigation. In other words, in the second alternative risk is considered, which affects the level of yields under rainfed agriculture. The hypothesis of this paper indicates that the levels of return to investment should be higher in the second alternative, considering that gross annual margins differ significantly in the two alternatives and more than yields.

6.1 Economics results of the switch from rainfed agriculture to irrigated agriculture considering expected yields in both situations

IRR calculation is based on the flow of funds shown in table 4. The value of the equipment is shown in row 2 (year 1); row 3 shows the gross margins with irrigation; row 4 shows the gross margins without irrigation; row 5 shows the annual differences between gross margins (irrigated and rainfed agriculture). Finally, row 6 shows the internal rate of return, which is of the order of 8%.

Cuadro 4: Profitability with constant returns in the passage from rainfed to irrigated agriculture

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Investment in irrigation	-948000														
Gross margin in irrigated agriculture	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600
Gross margin in rainfed agriculture	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283	241.283
Variation of gross margin	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317	100.317
Internal rate of return (IRR)	8%														

Source: Estimations based upon previous figures.

6.2 Economics results of the switch from rainfed agriculture to irrigated agriculture considering variability of yields in rainfed agriculture

The structure of the table is identical to the one shown in table 4. It should be noted that the annual differences between gross margins of irrigated and rainfed agriculture were built upon consideration of variable yields in rainfed production. The internal rate of return rises considerably, up to the value of 18%.

Cuadro 5: profitability with variables returns in the passage from rainfed to irrigated agriculture

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Investment in irrigation	-948.000														
Gross margin in irrigated agriculture	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600	341.600
Gross margin in rainfed agriculture	101.998	135.280	184.724	201.316	185.462	260.618	263.712	86.874	333.227	237.517	210.748	211.754	255.795	269.663	234.138
Variation of gross margin	239.602	206.320	156.876	140.284	156.138	80.982	77.888	254.726	8.373	104.083	130.852	129.846	85.805	71.937	107.462
Internal rate of return (IRR)	18%														

Source: Estimations based upon previous figures..

Comparison between tables 4 and 5 shows that when variables yields in rainfed agriculture are considered, the internal rate of return is remarkably higher. Furthermore, estimation considering risk conditions offers a more realistic view of the impact of complementary irrigation.

7. Conclusions

The conventional economic risk analysis models use Monte-Carlo methods for the selection of optimal crop combinations, taking into account risk factors, according to profitability criteria. The procedure consists of: (a) determining the risk variables (generally prices and climate) and their impact on yields; (b) determine the influence of said variables on the values of expected levels of profitability and variability of profits; (c) select that alternative that combines adequate levels of expected income with low variability in them. (Halter & Dean, 1985).

The contribution of this work consists in evaluating the economic impact of irrigation upon a single combination of productive activities, but differentiating between: (a) the part of economic benefits that irrigation brings about by change of expected income levels and (b) benefits associated with the reduction of yield-variability.

The use of historical data (in replacement of random numbers, regularly used in Monte Carlo analysis) allows to demonstrate that the main impact of complementary irrigation is associated with the reduction of yield-variability. The rate of return on investment more than doubles when risk analysis (stochastic values) substitutes the use of a deterministic model.

It is possible that these considerations are useful to highlight the importance of complementary irrigation in grain production. A tentative analysis in forage production reveals that risk reduction can have a similar influence (Plan Nacional de Riego, August 2017). We recommend that risk analysis be used in economic valuation of complementary irrigation for every crop in the province of Buenos Aires and widely in the Pampean Region.

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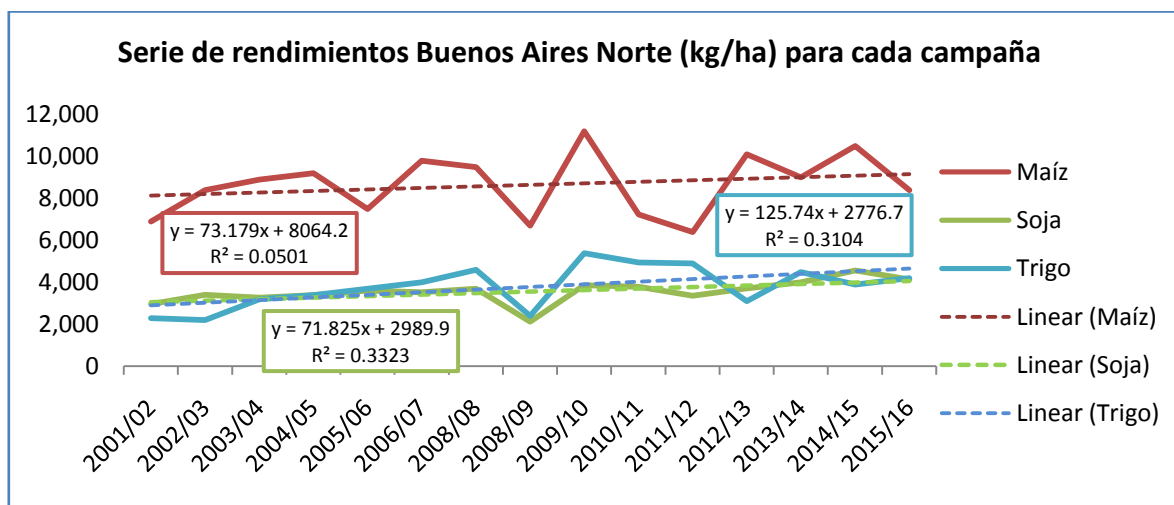
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9. Annexes:

Appendix 1:

Technological change and increase in yields:

Given that we have taken a broad series of 15 years, we observe a slight upward trend in the slope of yields that is explained by the adoption of new technologies that positively impact the yields of all crops, including corn. It is in this crop, where when performing a test of significance of the slope given by the regression against the time variable, it follows that there is technological change. This existence is explained because the slope of the linear regression against time differs statistically from zero, being the "t criticaltwotail" equal to 2.14. You can also see in the following graph the values of the slopes of crop yield trend lines, which are, in all cases, positive. In this way, it is observed again, as over time the average yields of each crop grow.



Source: own elaboration based on data from Minagro 2017.

Appendix 2:

a) Pergamino yields:

año	Mm	Pergamino			
		Maíz (kg/ha)	Soja (Kg/ha)	Soja 2° (Kg/ha)	Trigo (Kg/ha)
2001/02		6.900	2.970	1.634	2.286
2002/03		8.400	3.404	1.872	2.200
2003/04		8.900	3.272	1.800	3.200
2004/05		9.200	3.397	1.868	3.400
2005/06		7.500	3.603	1.982	3.700
2006/07	1290	9.800	3.536	1.945	4.000
2008/08	457	9.500	3.701	2.036	4.600
2008/09	659	6.700	2.122	1.167	2.400

2009/10	1099	11.200	3.873	2.130	5.396
2010/11	451	7.245	3.794	2.087	4.957
2011/12	626,4	6.400	3.363	1.850	4.900
2012/13	869	10.100	3.710	2.041	3.100
2013/14	989	9.000	4.010	2.206	4.500
2014/15	781	10.500	4.569	2.513	3.900
2015/16	835	8.400	4.143	2.279	4.200
Promediorinde	8.885	3.682	2.025	4.195	

b) Rendimientos en Arrecifes:

Arrecifes				
Año	Maíz (kg/ha)	Soja (Kg/ha)	Soja 2° (Kg/ha)	Trigo (Kg/ha)
2001/02	6.141	2.643	1.454	2.035
2002/03	7.476	3.030	1.666	1.958
2003/04	7.921	2.912	1.602	2.848
2004/05	8.188	3.023	1.663	3.026
2005/06	6.675	3.207	1.764	3.293
2006/07	8.722	3.147	1.731	3.560
2008/08	8.455	3.294	1.812	4.094
2008/09	5.963	1.889	1.039	2.136
2009/10	9.968	3.447	1.896	4.802
2010/11	6.448	3.377	1.857	4.412
2011/12	5.696	2.993	1.646	4.361
2012/13	8.989	3.302	1.816	2.759
2013/14	8.010	3.569	1.963	4.005
2014/15	9.345	4.066	2.237	3.471
2015/16	7.476	3.687	2.028	3.738
	7.907	3.277	1.802	3.734

Annex 3:

Prices taken:

The prices of grains corresponding to the average of the years 2013 to 2016 are considered. The corresponding estimates are shown in Table A and Chart B. The estimated values, of high reliability, were obtained from the website agroindustria.gob.ar (Undersecretariat of Agricultural Markets of the Ministry of Agribusiness of the Nation) and complemented by the information provided on the site agrofy.com.ar. They result after including the impact

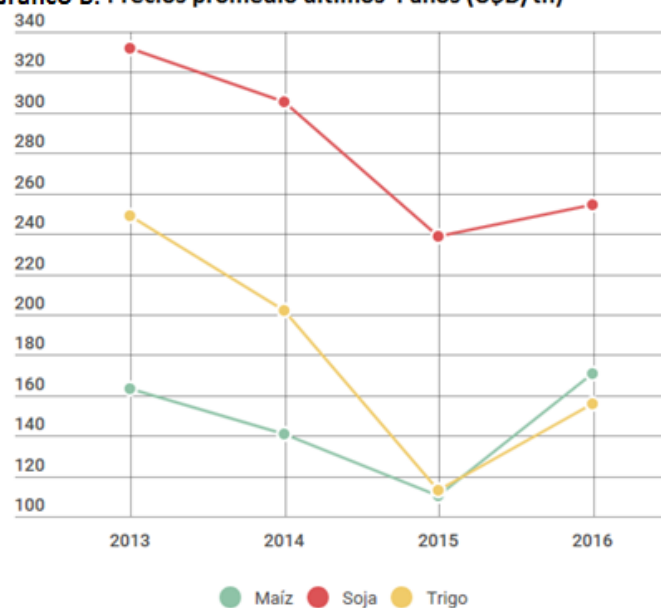
of export taxes or "withholdings" for each period or year between 2013 and 2015 (equivalent to 20% over price "fob" in corn, 23% in wheat and 35% in soybean). The prices consigned for 2016 do not include this impact because the withholdings are eliminated, with the exception of soybeans, which maintains a 30% rate during that year.

Table A: Average prices for the last 4 years (U \$ D / Tn) and explanatory chart B:

	Cultivo		
	Maíz	Soja	Trigo
Promedio 2013*	163	332	249
Promedio 2014*	141	305	202
Promedio 2015*	110	239	113
Promedio 2016*	171	254	156
PROMEDIO 4 AÑOS	146	282	180

Source: own elaboration based on data Minagro y agrofy.com.ar

Gráfico B: Precios promedio últimos 4 años (U\$D/tn)



Source: own elaboration based on data Minagro y agrofy.com.ar

Calculation of gross margins of the rotation Corn-Wheat- late soybean -Trigo for the period 2001-2016, respecting yields of the series presented in section 3 of this work.

OPEX año 1

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquimicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	2,2	2,8	1,5	6,5

Ingreso Bruto (USD/ha)	(USD/ha)	389	793	436	954
Gastos de Seguro	(USD/ha)	14	29	16	34
Gastos de cosecha	(USD/ha)	39	63	48	89
Gastos comerciales	(USD/ha)	94	163	90	261
Costos directos totales	(USD/ha)	288	479	322	761
Margen Bruto Secano	(USD/ha)	101	314	114	194

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	954	389	436	389	2.168	1084
Costos directos totales	(USD/ha)	761	288	322	288	1.658	829
Margen Bruto Secano	(USD/ha)	194	101	114	101	510	255

OPEX año 2

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquimicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	2,1	3,2	1,8	7,9

Ingreso Bruto (USD/ha)	(USD/ha)	374	909	500	1.162
Gastos de Seguro	(USD/ha)	13	33	18	42
Gastos de cosecha	(USD/ha)	37	73	55	89
Gastos comerciales	(USD/ha)	90	187	103	317
Costos directos totales	(USD/ha)	282	516	345	825
Margen Bruto Secano	(USD/ha)	92	392	155	337

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.162	374	500	374	2.410	1205
Costos directos totales	(USD/ha)	825	282	345	282	1.734	867
Margen Bruto Secano	(USD/ha)	337	92	155	92	676	338

OPEX año 3

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	USD/Ton	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	3,0	3,1	1,7	8,4

Ingreso Bruto (USD/ha)	(USD/ha)	544	873	480	1.231
Gastos de Seguro	(USD/ha)	20	31	17	44
Gastos de cosecha	(USD/ha)	54	70	53	89
Gastos comerciales	(USD/ha)	131	180	99	336
Costos directos totales	(USD/ha)	346	505	338	846
Margen Bruto Secano	(USD/ha)	198	368	142	385

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.231	544	480	544	2.800	1400
Costos directos totales	(USD/ha)	846	346	338	346	1.877	938
Margen Bruto Secano	(USD/ha)	385	198	142	198	924	462

OPEX año 4

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	3,2	3,2	1,8	8,7

Ingreso Bruto (USD/ha)	(USD/ha)	578	907	499	1.272
Gastos de Seguro	(USD/ha)	21	33	18	46
Gastos de cosecha	(USD/ha)	58	73	55	89
Gastos comerciales	(USD/ha)	139	187	103	347
Costos directos totales	(USD/ha)	359	516	344	859
Margen Bruto Secano	(USD/ha)	219	391	154	413

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.272	578	499	578	2.928	1464
Costos directos totales	(USD/ha)	859	359	344	359	1.921	961
Margen Bruto Secano	(USD/ha)	413	219	154	219	1.007	503

OPEX año 5

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	USD/Ton	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	3,5	3,4	1,9	7,1
Ingreso Bruto (USD/ha)	(USD/ha)	630	962	529	1.037
Gastos de Seguro	(USD/ha)	23	35	19	37
Gastos de cosecha	(USD/ha)	63	77	58	89
Gastos comerciales	(USD/ha)	152	198	109	283
Costos directos totales	(USD/ha)	378	533	355	786
Margen Bruto Secano	(USD/ha)	251	428	174	251

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.037	630	529	630	2.825	1413
Costos directos totales	(USD/ha)	786	378	355	378	1.898	949
Margen Bruto Secano	(USD/ha)	251	251	174	251	927	464

OPEX año 6

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	3,8	3,3	1,8	9,3
Ingreso Bruto (USD/ha)	(USD/ha)	681	944	519	1.355
Gastos de Seguro	(USD/ha)	24	34	19	49
Gastos de cosecha	(USD/ha)	68	76	57	89
Gastos comerciales	(USD/ha)	164	194	107	370
Costos directos totales	(USD/ha)	398	528	352	885
Margen Bruto Secano	(USD/ha)	283	416	168	471

Ingreso Neto para rotación	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	0	944	1.355	944	3.243	1622
Costos directos totales	(USD/ha)	0	528	885	528	1.940	970
Margen Bruto Secano	(USD/ha)	0	416	471	416	1.303	652

OPEX año 7

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	4,3	3,5	1,9	9,0
Ingreso Bruto (USD/ha)	(USD/ha)	783	988	543	1.314
Gastos de Seguro	(USD/ha)	28	36	20	47
Gastos de cosecha	(USD/ha)	78	79	60	89
Gastos comerciales	(USD/ha)	189	204	112	359
Costos directos totales	(USD/ha)	436	542	360	872
Margen Bruto Secano	(USD/ha)	347	446	183	442

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.314	783	543	783	3.423	1711
Costos directos totales	(USD/ha)	872	436	360	436	2.104	1052
Margen Bruto Secano	(USD/ha)	442	347	183	347	1.319	659

OPEX año 8

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	2,3	2,0	1,1	6,3
Ingreso Bruto (USD/ha)	(USD/ha)	408	566	312	927
Gastos de Seguro	(USD/ha)	15	20	11	33
Gastos de cosecha	(USD/ha)	41	45	34	89
Gastos comerciales	(USD/ha)	98	117	64	253
Costos directos totales	(USD/ha)	295	406	278	752
Margen Bruto Secano	(USD/ha)	113	160	33	175

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	927	408	312	408	2.055	1027
Costos directos totales	(USD/ha)	752	295	278	295	1.620	810
Margen Bruto Secano	(USD/ha)	175	113	33	113	434	217

OPEX año 9

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maiz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquimicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	5,1	3,7	2,0	10,6

Ingreso Bruto (USD/ha)	(USD/ha)	918	1.034	569	1.549
Gastos de Seguro	(USD/ha)	33	37	20	56
Gastos de cosecha	(USD/ha)	92	83	63	89
Gastos comerciales	(USD/ha)	221	213	117	423
Costos directos totales	(USD/ha)	487	557	369	944
Margen Bruto Secano	(USD/ha)	431	477	200	605

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.549	918	569	918	3.954	1977
Costos directos totales	(USD/ha)	944	487	369	487	2.288	1144
Margen Bruto Secano	(USD/ha)	605	431	200	431	1.666	833

OPEX año 10

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maiz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquimicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	4,7	3,6	2,0	6,8

Ingreso Bruto (USD/ha)	(USD/ha)	843	1.013	557	1.002
Gastos de Seguro	(USD/ha)	30	36	20	36
Gastos de cosecha	(USD/ha)	84	81	61	89
Gastos comerciales	(USD/ha)	203	209	115	274
Costos directos totales	(USD/ha)	459	550	365	775
Margen Bruto Secano	(USD/ha)	384	463	192	227

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.002	843	557	843	3.246	1623
Costos directos totales	(USD/ha)	775	459	365	459	2.058	1029
Margen Bruto Secano	(USD/ha)	227	384	192	384	1.188	594

OPEX año 11

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + In	USD/ha	49	49	56	146
Agroquímicos	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Com	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de	USD/ha	1	1,8	1,8	1,8

Precio (MaT	(USD/Ton)	180	282	282	146
Rendimiento	(Ton/ha)	4,6	3,2	1,7	6,0
Ingreso Bruto	(USD/ha)	834	898	494	885
Gastos de	(USD/ha)	30	32	18	32
Gastos de	(USD/ha)	83	72	54	89
Gastos con	(USD/ha)	201	185	102	242
Costos direct	(USD/ha)	455	513	343	739
Margen Bruto	(USD/ha)	378	385	151	146

Ingreso Neto	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	885	834	494	834	3.046	1523
Costos directo	(USD/ha)	739	455	343	455	1.992	996
Margen Bruto	(USD/ha)	146	378	151	378	1.054	527

OPEX año 12

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	2,9	3,5	1,9	9,5
Ingreso Bruto (USD/ha)	(USD/ha)	527	990	545	1.397
Gastos de Seguro	(USD/ha)	19	36	20	50
Gastos de cosecha	(USD/ha)	53	79	60	89
Gastos comerciales	(USD/ha)	127	204	112	381
Costos directos totales	(USD/ha)	340	543	361	897
Margen Bruto Secano	(USD/ha)	188	448	184	499

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Tr	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.397	527	545	527	2.996	1498
Costos directos totales	(USD/ha)	897	340	361	340	1.938	969
Margen Bruto Secano	(USD/ha)	499	188	184	188	1.059	529

OPEX año 13

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	4,3	3,8	2,1	8,5

Ingreso Bruto (USD/ha)	(USD/ha)	766	1.070	589	1.245
Gastos de Seguro	(USD/ha)	28	39	21	45
Gastos de cosecha	(USD/ha)	77	86	65	89
Gastos comerciales	(USD/ha)	185	221	121	340
Costos directos totales	(USD/ha)	430	568	376	850
Margen Bruto Secano	(USD/ha)	336	502	213	394

Ingreso Neto para rotación Maíz	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.245	766	589	766	3.365	1682
Costos directos totales	(USD/ha)	850	430	376	430	2.086	1043
Margen Bruto Secano	(USD/ha)	394	336	213	336	1.279	639

OPEX año 14

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquímicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	3,7	4,3	2,4	9,9

Ingreso Bruto (USD/ha)	(USD/ha)	664	1.220	671	1.452
Gastos de Seguro	(USD/ha)	24	44	24	52
Gastos de cosecha	(USD/ha)	66	98	74	89
Gastos comerciales	(USD/ha)	160	251	138	396
Costos directos totales	(USD/ha)	391	617	405	915
Margen Bruto Secano	(USD/ha)	272	603	266	538

Ingreso Neto para rotación Maíz - T	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.452	664	671	664	3.450	1725
Costos directos totales	(USD/ha)	915	391	405	391	2.102	1051
Margen Bruto Secano	(USD/ha)	538	272	266	272	1.348	674

OPEX año 15

SECANO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquimicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8

Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	4,0	3,9	2,2	7,9
Ingreso Bruto (USD/ha)	(USD/ha)	715	1.106	608	1.162
Gastos de Seguro	(USD/ha)	26	40	22	42
Gastos de cosecha	(USD/ha)	71	88	67	89
Gastos comerciales	(USD/ha)	172	228	125	317
Costos directos totales	(USD/ha)	410	580	383	825
Margen Bruto Secano	(USD/ha)	304	526	225	337

Ingreso Neto para rotación Maíz -	Unidad	Maíz	Trigo	Soja de 2°	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.162	715	608	715	3.199	1600
Costos directos totales	(USD/ha)	825	410	383	410	2.028	1014
Margen Bruto Secano	(USD/ha)	337	304	225	304	1.171	585

Annex 4

Costos directos de producción bajo riego zona norte de Buenos Aires

COSTOS BAJO RIEGO	Unidad	Trigo	Soja de 1°	Soja de 2°	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	59	67	161
Agroquimicos	USD/ha	40	117	56	163
Riego	USD/ha	60	98	75	116
Milímetros	mm / ha	80	130	100	150
Energía	USD / mm	0,70	0,70	0,70	0,70
Operación del equipo	USD / mm	0,05	0,05	0,05	0,07
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	7,5%	6,5%
Gastos Comerciales	% IB	24,1%	20,6%	22,0%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8
Precio (MaT USD/Ton)	(USD/Tn)	180	282	282	146
Rendimiento (Tn/ha)	(USD/Tn)	5,0	5,3	2,6	13,9
Ingreso bruto (USD/ha)	(USD/ha)	905	1.504	734	2.039
Gastos de Seguro	(USD/ha)	33	54	26	73
Gastos de cosecha	(USD/ha)	90	120	55	133
Gastos comerciales	(USD/ha)	218	310	162	557
Costos directos totales	(USD/ha)	547	842	511	1.270
Riego / Costo Directos		11%	12%	15%	9%
Margen Bruto Riego	(USD/ha)	357	662	223	770

Gross partial margins by crop:

RIEGO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Ingreso Bruto	(USD/ha)	905	1.504	734	2.039
Costos directos totales	(USD/ha)	547	842	511	1.270
Margen Bruto Riego	(USD/ha)	357	662	223	770

Gross margin of the bi-annual rotation Corn-wheat-late soybean -trigo.

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	2.039	905	734	905	4.583	2292
Costos directos totales	(USD/ha)	1.270	547	511	547	2.875	1438
Margen Bruto Riego	(USD/ha)	770	357	223	357	1.708	854

Annex 5

Operating costs and calculation of gross margin by individual crop for rainfed production.

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Costos Directos					
Labores	USD/ha	56	83	68	66
Semillas + Inoc	USD/ha	49	49	56	146
Agroquimicos + fert	USD/ha	35	90	43	163
Seguro	% IB	3,6%	3,6%	3,6%	3,6%
Cosecha	% IB	10,0%	8,0%	11,0%	7,0%
Gastos Comerciales	% IB	24,1%	20,6%	20,6%	27,3%
Gastos de monitoreo	USD/ha	1	1,8	1,8	1,8
Precio (MaT USD/Ton)	(USD/Ton)	180	282	282	146
Rendimiento (Ton/ha)	(Ton/ha)	4,0	3,6	2,0	8,5
Ingreso Bruto (USD/ha)	(USD/ha)	720	1.017	565	1.244
Gastos de Seguro	(USD/ha)	26	37	20	45
Gastos de cosecha	(USD/ha)	72	81	62	89
Gastos comerciales	(USD/ha)	174	209	116	340
Costos directos totales	(USD/ha)	412	551	368	850
Margen Bruto Secano	(USD/ha)	308	466	197	394

Gross margin of the rotation Corn-wheat- late soybean -wheat for rainfed production.

SECANO	Unidad	Trigo	Soja de 1º	Soja de 2º	Maíz
Ingreso Bruto	(USD/ha)	720	1.017	565	1.244
Costos directos totales	(USD/ha)	412	551	368	850
Margen Bruto Secano	(USD/ha)	308	466	197	394

Ingreso Neto para rotación Maíz - Trigo - Soja 2a - Trigo	Unidad	Maíz	Trigo	Soja de 2º	Trigo	Suma	Suma/2
Ingreso Bruto	(USD/ha)	1.244	720	565	720	3.249	1625
Costos directos totales	(USD/ha)	850	412	368	412	2.043	1021
Margen Bruto Secano	(USD/ha)	394	308	197	308	1.206	603