AN ECONOMIC EVALUATION OF THE ANIMAL-DRAWN SEED DRILL IN THE SEMI-ARID REGION OF MOROCCO

R.K. BANSAL, BITNEY L.L., BENAOUDA H., and EL GHARRAS O.

INTRODUCTION

Agricultural mechanization has received considerable emphasis from the Government of Morocco, particularly since 1981 when substantial state subsidies were made available to farmers for the purchase of tractors and other farm equipment (MARA 1987). Many farmers now use tractors either through ownership or custom hiring. But the use of tractors is limited mostly to tillage and transport. For cereal production, it has been estimated that up to 70% of the area under wheat and barley is tilled by tractors. However, very little of that area is sown by tractor drawn seed drills. Most farmers sow cereals by hand broadcasting followed by one pass of a tractor-drawn offset disc harrow (cover crop) for seed covering. This method of sowing gives wide variation in seeding depth which causes variations in plant emergence and growth (Bouaziz and Bruckler, 1989). Some seed near the soil surface is lost because either it does not germinate or eaten away by birds. In order to obtain an adequate plant population, farmers use a very high seeding rates of up to 200 kg/ha for both wheat and barley (Boughlala et al., 1989).

Agronomy experiments conducted in the semi-arid region of Morocco have

shown that by using a seed drill, seeding rates can be reduced to about 120 kg/ha for wheat and 90 kg/ha for barley, often with positive results on yields (Boutfirass, 1986). This leads us to develop an animal-drawn seed drill especially for small and medium sized farms in Morocco. This paper briefly describes the animal-draw seed drill developed by the Centre Regional de la Recherche Agronomique (CRRA), Settat and covers an economic analysis of that machine based on data collected from on farm experiments in 1989-90 and 1990-91.

Description

The animal-drawn seed drill is a five-row machine with a maximum distance of 1 m between the end rows. Thus, for cereals sown in 20-cm spaced rows, the effective width of the machine is 1 m. For other crops such as lentils and safflower, row spacing can be adjusted by shifting the furrow openers and removing some of them. A roller feed mechanism described in detail elsewhere (Bansal et al., 1989) has been used for seed metering. Seeding rate is adjusted by varying the space between two nylon rollers located inside an aluminium casting. There are five identical aluminium castings, one for each row, fixed to the underside of the seed hopper. Fertilizer application rate is controlled by varying the size of an opening located near the bottom of the hopper. Inside the fertilizer hopper, there are five fluted rollers mounted on a shaft. These fluted rollers push fertilizer through the openings in the hopper when the shaft turns.

Both seed and fertilizer metering mechanisms are powered from the left wheel of the seed drill through a chain drive. There is a clutch in the power transmission system to stop the flow of seeds and fertilizer when the furrow openers are raised by pulling a hand operated lever. The seed drill requires a pair of draft animals for a smooth operation although under good working conditions a single horse or a mule may be sufficient.

Testing and on-farm evaluation

The animal-drawn seed drill has been evaluated for three years at research stations and on-farm locations. The main objective of on-station testing was to study functional and mechanical performance of the machine for sowing different crops. On-farm evaluation was done to study the performance of the seed drill in farmer's fields with their animals and also to receive farmer's comments.

In 1989-90, an experiment was started at Jemaa Sahim and Khamis Zemamra research stations to study the potential impact of the seed drill in a wheat production system, with and without chemical weed control. The seed drill was compared with farmer's method of wheat production which included broadcast sowing at 140 kg/ha seeding rate. In sowing with the seed drill, seeding rate was adjusted to 100 kg/ha. Plots sown with the farmer's method and with the seed drill were sub-divided to impose the chemical weed control treatment, which was one post-emergence application of Buctril at 2 l/ha.

On-farm testing of the seed drill was started in 1986-87. Initially, the objectives of this study were to evaluate the performance of the seed drill with farmer's animals, and to obtain feedback from farmers. These tests were mostly conducted on Vertisols (tirs) around Settat and Jemaa Shaim. Based on the experience from on-farm research, the design of the seed drill was progressively improved. Subsequently, the objectives of the onfarm work were expanded to include demonstrations and economic evaluation of the seed drill in a variety of soils in Chaouia, Jemaa Shaim, and Chemaia regions. Its performance was best in well prepared seedbed conditions. In October 1990 at Chemaia, the animal-drawn seed drill worked well in a no-till condition also where light sandy soils had softened by rains received a few days earlier.

In the 1990-91 cropping season, there were experiments at four on-farm locations in Abda and Chaouia regions where sowing by the seed drill was compared with the farmer's method of sowing wheat. The cooperating farmers used a high seeding rate of 180-200 kg/ha in plots sown by broadcasting seeds. With the seed drill two seeding rates of 120 kg/ha and 150 kg/ha were used. All the other factors such as seedbed preparation (2 passes of cover crop) and fertilizer use were common. The plot size was 0.3 ha or larger.

RESULTS AND DISCUSSION

Seed drill field performance data for 2 years of testing at on-farm locations is summarized in Table 1. The average effective field capacity of the seed drill was 0.30 ha/h, meaning that on an average about 3.4 hours were needed to sow 1 ha area. The actual time needed for sowing one hectare area varied form 2.5 hours to 4 hours depending upon the crop, field conditions, animals, and the operator. It was observed that under usual working conditions, animals belonging to farmers had no difficulty in pulling the machine. Only when there was not enough time to get animals and the operator accustomed to the machine before the start of sowing, were the rows not straight and the distance between successive passes was not properly maintained.

Table I : **Field performance of the animal-drawn seed drill at on-farm locations in 1986-87 and 1989-90.**

Location	Crop	Area (ha)	Filed length (m)	Ave. Speed (m/s)	EFC (a) (ha/h)	Hours
1986-87						
Sidi El Aydi	Wheat	0.45	168.0	1.10	0.35	2.85
	Lentil	0.95	180.0		0.28	3.57
Douar Chofra	Barley	0.90	180.0	1.07	0.29	3.45
Douar Zawagha	Lentil	0.22	56.0		0.26	3.84
1989-90						
Sidi El Aydi	Pea	1.20	130.0	1.05	0.42	2.38
N'Zagh	Wheat	1.35	75.0	0.94	0.28	3.57
Jemaa Sahim	Wheat	0.18	60.0	0.90	0.29	3.45
Average		0.76	123.6	1.00	0.30	3.43

(a) EFC - Effective field capacity.

Grain and straw yields from the experiment conducted in 1989-90 at the Jemaa Sahim and Khamis Zemamra stations are summarized in Table 2. This data showed that both chemical weed control and the seed drill made a positive effect on grain yield. At Jemaa Sahim, grain yield improved by 5.9% (from 1840. 4 to 1949. 4 kg/ha) by using the seed drill instead of sowing by broadcasting. The chemical weed control was more effective in a drill sown plot than in a broadcast sown plot as the grain yield improved to 2025. 2 kg/ha from 1895. 3 kg/ha. At Khamis Zemamra, average grain yield was higher by 10. 4% in the drill sown plots compared to that from plots sown by the farmer's method (Table 2). But the chemical weed control was apparently better in broadcast sown plots than in drill sown plots. The experiment at Khamis Zemamra station had a serious weed problem from the very beginning. In those plots not treated with herbicide, hand weeding was done once to save the experiment from a complete swamping by weeds. Evidently, hand weeding was not as effective as the herbicide.

Table II : **Wheat grain and straw yields (kg/ha) and percentage increase over control treatment by adding new inputs, 1989-90.**

TREATMENT	Jemaa-Sahim				Khamis Zemamra			
	Grain yield	(%)	Straw yield	(%)	Grain yield	(%)	Straw yield	(%)
Control	1840.4		2980.8		1414.5		2051.3	
Control+WC	1895.3	3.0	2286.3	-23.3	1963.7	38.8	2179.5	6.2
SD	1949.4	5.9	3098.3	3.9	1562.0	10.4	2948.7	43.7
SD + WC	2025.2	10.0	2318.4	- 22.2	1737.2	22.8	2111.1	2.9

Control - Farmer's method of sowing

WC - Chemical Weed control ; SD - Seed drill

At both locations straw yield was less in plots that received chemical weed control. The reason for this was that the straw from the plots not treated with herbicide had weeds mixed with it and thus weighed more. Seed drill effect was positive on straw yield at both locations. This experiment showed that by using a seed drill, wheat seeding rate can be lowered to about 100 kg/ha from 140 kg/ha or more that farmers use now and still obtain better yields for both grain and straw. Actually, farmers in Abda region use up to 200 kg/ha seeding rate. They can easily save 60 to 80 kg seed per hectare.

Table 3 shows average grain yields obtained at four on-farm locations in 1990-91 from plots sown by broadcasting (farmer's method) and by the animal-drawn seed drill. It is apparent from Table 3 that using an animal-drawn seed drill at a seeding rate of 120 kg/ha produced a better grain yield at all the four locations than the farmer's method using 180 kg/ha seeding rate. The actual yield difference varied considerably from one location to the other. This was probably a function of both the variety used and the crop rotation. In general, yields were higher in plots that had food legumes in the previous years (at Oulad Saïd and Settat).

The average yield for all four locations was 152 kg/ha (about 7%) higher than the average yield from farmer's method. The effect of a higher seeding rate

(150 kg/ha) was somewhat inconsistent. At two locations the higher seeding rate lowered the grain yield, whereas, on the other two locations it produced better yield compared to the corresponding yields with 120 kg/ha seeding rates. Perhaps a high plant population and the early season drought at some locations adversely affected grain yields.

Table III : **Summary of wheat yields (kg/ha) obtained at on-farm experiments at four locations, 1990-91.**

Sowing method	Seeding rate (kg/ha)	Locations				Average	Percent over farmer's method
		I	II	III	IV		
			grain yields (kg/ha)				
Seed drill	120	2880	1966	2690	1686	2305	7.1
Seed drill	150	2480	2080	2550	1863	2243	4.2
Farmer's method	180	2426	1926	2663	1596	2153	Base yields

Economic Evaluation

While it is recognized that a farmer will consider several factors in the decision to purchase a seed drill, profitability is the basic. If the farmer perceives it to be a profitable investment, only then do other considerations become important. These include social considerations, willingness to invest in a new machine, and farmer's ability to acquire new skills to operate and maintain the seed drill. The seed drill represents a major investment, especially for those farmers who do not already possess other farm equipment of significant value. Credit will probably be required to purchase the seed drill. It represents a new technology for many Moroccan farmers. While it has been tested on experiment stations and many on-farm locations, there is still an element of risk, as to how it will work on a given farm, on several crops, and over a period of years.

The potential benefits, as compared to hand sowing, include : less seed required, higher yields of grain and straw, and possible saving of one tractor pass

usually required for seed covering. The potential costs are : annual fixed costs, depreciation, interest on the investment, shelter or increased wear due to exposure, repairs, and draft animals - ownership or rental cost.

To estimate the annual fixed costs of the seed drill, the current price of 12000 dirhams charged by the manufacturer was accepted. The seed drill qualifies for a government subsidy up to 50% of the price. Thus, the effective cost of the seed drill to a farmer is 6000 dirhams. Depreciation was calculated considering 8 years useful life and 600 dirhams (10%) salvage value. The actual useful life will depend on the care and maintenance, annual use, and when it becomes obsolete. Thus, the annual depreciation was calculated as 675 dirhams. Average annual interest on investment was calculated to be 396 dirhams, assuming 12% interest on an average undepreciated balance of 3300 dirhams over the 8 year life.

Further, an additional one percent of the purchase price (60 dirhams) per year was allowed for shelter, or to the added wear and tear due to lack of shelter. Thus, the total annual fixed cost was estimated as 1131 dirhams which includes depreciation (675 dirhams), interest (396 dirhams), and shelter cost (60 dirhams).

On a unit area basis, fixed costs were calculated as 226, 113, 75, and 57 dirhams per hectare for four levels of assumed annual use of 5, 10, 15, and 20 hectares, respectively. Clearly, the fixed cost per hectare is very sensitive to the level of annual use. It is also the largest component of the total cost of owning and operating the seed drill. While seeding 20 hectares per year results in a lower fixed cost per hectare, this level of use may not be possible for many farmers. The size of farm, the mix of crops seeded, the extent of custom seeding done for other farmers, and the number of days suitable for operating the seed drill during planting season are factors that will determine the level of annual use of the seed drill. Therefore, 20 hectares of annual use for the seed drill was considered maximum.

The variable costs of a machine typically include repairs and maintenance. Maintenance of the seed drill includes lubrication and frequent inflation of tires. These costs are so small that for this analysis they were neglected. A standard agricultural engineering formula was used to calculate repair costs for the seed drill. It takes into account the purchase price of the machine and its annual use for estimating the repair cost. With the formula suggested by Rotz (1987) repair costs per hectare increase as annual use goes up. Using Rotz (1987) experience, seed drill repair costs were estimated as 2.35, 5.05, 7.88, and 10.82 dirhams per

hectare for 5, 10, 15, and 20 hectares annual uses, respectively. Other items under variable costs are labor and draft animals which do not change with the annual use of the machine. It was assumed that in an average working day 2-hectares can be sown with the animal-drawn seed drill. Considering 40 dirhams/day for skilled worker and 30 dirhams/day rental charge for a pair of draft animals, labor and animals costs per hectare would be 20 and 15 dirhams, respectively. The fixed, variable, and total costs per hectare, for selected levels of annual use are summarized in Table 4.

Table IV : **Cost of seed drill use per hectare at four levels of annual use.**

Hectares Per Year	Fixed Costs	Repairs	Labor	Animals	Total Cost
		Dirhams per hectare			
5	226	2	20	15	263
10	113	5	20	15	153
15	75	8	20	15	118
20	57	11	20	15	103

Economic analysis

Once the operating cost of the seed drill has been determined, the next step is to find out if it is economical for small and medium-sized farms in Morocco. In this paper, the economic viability of the seed drill has been evaluated by partial budgeting for a wheat crop in two different ways as described below.

A. Economic cost approach

A partial budget, as its name implies, includes only certain parts of the cost and return for an enterprise that are affected by the change. In this case, only those items which change with the introduction of the seed drill are included. Items which do not change are ignored. It is assumed that the net revenue from the enterprise will change by the amount of the "net change" in the partial budget. While it is possible to use the seed drill to plant several crops, it is easier

to look at the effect on one major crop. The impact of using the animal-drawn seed drill on one hectare of bread wheat in the Upper Chaouia region was estimated. The analysis is presented in Table 5.

In addition to an estimation of the change in revenue, the partial budget also allows exploration of the sensitivity of each factor. Research reported earlier in this paper showed 6 to 10.5% increased grain yields with the seed drill. Using the five year average of bread wheat yields in Settat province of approximately 1200 kg/ha as a base, a yield increase of 8.3%, or 100 kg/ha was estimated for use in the partial budget. It is possible that some farmers would not have any increased yield.

Table V : **Estimated impact of using an animal-drawn seed drill instead of hand sowing, on one hectare of bread wheat.**

	Units	Price	Amount
I. Added Returns			(dh/ha)
Increased grain yield	100 kg	2.30	230.00
Less seed required	50 kg	3.30	165.00
Custom hire - cover crop			85.00
Labor savings	5.5 h	3.00	16.50
Total of items that increase revenue			496.50
II. Added Costs			
Cost of Seed drill (10 ha of use per year)			118.00
Animal use			15.00
Added harvest & storage costs of increased yield			3.00
Total added cost			136.00
Net Change in Revenue (I - II)			360.50

The seed savings depend on the seeding rate a farmer uses with hand sowing and the rate he decides to use when using the seed drill. Considering that farmers often use 180-200 kg/ha seed for wheat, and that the seed drill can produce equivalent or better yields with 120 kg/ha, an estimated seed savings of 50 kg/ha seems conservative. In the partial budget analysis, seed price was taken as 3.30 dh/kg. Thus, seed saving was estimated at 165 dh/ha which is a major factor affecting the economics of the seed drill.

Further, there may be a saving of one pass of disc harrow (cover crop) usually needed for seed covering which will not be required if a seed drill is used. Similarly, when the seed drill is used, there is no need for labor other than the operator for the machine. The figure of 5.5. hours per hectare in Table 5 is based on the labor needed for hand broadcasting seeds and fertilizer in the traditional method of sowing wheat (Rafsnider and Laamari, 1990b). The cost of the operator for the seed drill is already included in the variable cost calculated in Table 4.

On the added costs side, fixed costs and the costs incurred toward repairs were taken for 10 ha annual use of the seed drill in the partial budget. Howerver, this factor may vary considerably and will have a major effect on the economics. As already discussed earlier in this paper, an estimated rental rate of 15 dirhams per hectare was used to reflect the cost of draft animals.

The net change in revenue from using the animal-drawn seed drill on one hectare of bread wheat was estimated as 360.50 dirhams. This appears to be of a magnitude that would make the use of the seed drill feasible. The key factor in the feasibility for a given farmer is the number of crop hectares that he plants with the seed drill. Any farmer investing in the seed drill should try to maximize its use to keep the fixed cost component as low as possible. Rafsnider et al. (1990a and 1990b) reported from surveys that average medium farmer in Chaouia region cultivated 19.5 ha of land out of which 13.1 ha was under those crops that could be sown by the seed drill. In Abda region, an average medium farmer had 14.5 ha of land with only 8.6 ha under such crops. Average land under wheat and barley was 7.7 ha in Abda compared to 9.3 ha in Chaouia. If a farmer uses the seed drill primarily on his own farm, then it would appear that the seed drill is likely to be more profitable in the Chaouia than in the Abda region.

The net change in revenue which was estimated in Table 5 seems to be sufficient to allow some margin of error. For instance, if no increasin grain yield occurred, the change in revenue would be reduced by 230 dirhams, but would still be positive, at 130.50. There is also the possibility that the change in revenue could be greater than 360.50 dirhams per hectare. Use of the seed drill may also give increased straw yields, which were not considered in the partial budget analysis.

B. Cash flow approach

This method purtains to the financial analysis of the seed drill in terms of

farmer's obligation for loan payment. Using the information in the partial budget in Table 5, we can estimate how many hectares of bread wheat a farmer would need in order to meet the probable loan payments (principal and interest) on the seed drill. To do this, we remove the depreciation and interest charges as costs from the partial budget. From Table 4, we see that these costs are 113 dirhams per hectare. When these costs are removed, the net change in revenue is 473.50 dirhams per hectare (360.50 + 113). This is essentially a return to the investment in the seed drill, and is the maximum that a farmer would have for principal and interest payments.

If a farmer were to borrow 6000 dirhams at 12% interest, for a eight year term, the amortized annual payments would be 1110 dirhams. Dividing 1110 by 473.50 indicates that the farmer would need 2.4 hectares of bread wheat in order to generate enough increased revenue to meet the loan payments each year. This is a break-even point. If he could use the seed drill on more area, there would be additional revenue generated to allow for some margin of error. This analysis can also be extended to determine the sensitivity of some of the key assumptions in the partial budget. For example, if the farmer realized no yield increase, then his revenue would reduce to 243.50 dirhams/ha from 473.50 and he would then need 4.6 hectares of bread wheat, instead of 2.4, in order to meet the loan payments.

Potential constraints to seed drill adoption

The price of the seed drill might prove to be a major contraint to its successful diffusion. Typically, farmers will engage in limited experimentation with new inputs before making decisions concerning major commitments to their purchase and use. The seed drill, however, does not lend itself to such experimentation, yet its purchase might well involve the largest single financial commitment that the operator of a medium size farm would ever have had to make. The cash benefit shown in Table 5 would also be reduced if the farmer draws on his own store for barley seed grain, and uses annual production as feed for his own animals. Barley is the most important single crop in the medium size farm portfolio, accounting for 41 per cent of the total hectares that might be planted with the drill.

Commercial Production of The Seed Drill

The development of the animal-drawn seed drill has reached a very advanced stage. We have been encouraging small manufacturers in Morocco to start

commercilizing this machine. So far we have worked with two companies. One of them, RIAM at Settat, has made about 15 seed drills in past 2 years. But there are still many problems. It seems to us that there is not enough interaction between scientists and the manufacturer, and between the manufacturer and buyers. The manufacturer does not seem to appreciate the importance of standardization of production processes for making better quality machines and the need to develop a plan for after-sales technical support to buyers. On the other hand, the market looks so small that a manufacturer can not invest too much in the development of a proper production process.

Summary and Conclusions

As a result of good efforts to promote agricultural mechanization on the national level in Morocco, many farmers use tractors for farm operations. However, the use of tractor is mostly limited to tillage and transport. Cereal crops are mostly sown by hand broadcasting followed by a tractor-drawn cover crop for seed covering. Food legumes are usually sown by hand behind an animal-drawn plow. It appears that there is a good potential for an animal-drawn seed drill, especially for small and medium sized farms. An animal-drawn seed drill has been developed at CRRA, Settat for sowing cereals (wheat and barley) and a some other crops like lentils,safflower, and peas.

Three years of on-station and on -farm evaluation has shown that il performs welle under a variety of conditions. The results showed that with the seed drill seeding rate for wheat can be reduced from 180-200 kg/ha used by farmers at present to about 120 kg/ha with often a positive effect on grain yield.

An economicanalysis showed that the cost of seed drill use on 1 -ha area depends very much on its total annual use. It varies from 103 Dh/ha for 20-ha annual use to 263 Dh/ha for 5-ha annual use. Thus, any farmer owing an animal-drawn seed drill should try to make a maximum use of it. The economic analyses also showed that the investment in a seed drill is viable even if no extra yield advantage is realized, provided it could be used on at least 4.6-ha aera in a year.

Some problems have been experienced in getting the seed drillmanufactured in the private sector. Widespread use of the seed drill would depend on finding one or more firms to manufacture the seed drill. Product support, in the form of training in calibration and operation of the seed drill, and repair parts would also be needed.

ABSTRACT

This paper describes an animal-drawn seed drill designed for sowing small grain cereals, like wheat and barley, and food legumes mainly lentils and peas. It can also apply fertilizer along with sowing in the same pass. It takes 3 to 4 hours to sow one hectare area depending up on animals and working conditions. The investment in the seed drill is profitable to small and medium farmers because it saves seed, 50 to 60 kg/ha for wheat and barley, and often gives beter yields. An economic study showed that a farmer should use the machine on at least 4.6 ha area per year.

RESUME

Cet article décrit un semoir à traction animale conçu pour le semis de céréale, comme le blé et l'orge, et de légumineuse alimentaire, comme la lentille et le petit pois.

C'est une machine combinée qui peut en même temps que le semis, épandre l'engrais. L'opération de semis d'un hectare utilisant ce semoir nécessite 3 à 4 heures selon les conditions de travail et des animaux de traits.

L'investissement dans cette machine est profitable aux petits et moyens agriculteurs parce qu'elle économise les semences, 50 à 60 kg/ha pour le blé et l'orge, et souvent permet de meilleurs rendements. Une étude économique a montré qu'un agriculteur doit utiliser ce semoir sur une superficie d'au moins 4,6 ha par an pour que l'investissement soit justifiable.

ملخص

يصف هذا المقال بذارة مجرورة بالحيوان تم إنجازها من أجل الحبوب كالقمح والشعير والقطاني كالعدس والبازلاء.

يمكن للبذارة أن تقوم بعملية الزرع ونشرالسماد في آن واحد. وتحتاج عملية بذر هكتارواحد مابين 3 و 4 ساعات حسب شروط الحرث ونوعية حيوانات الجر.

استخدام البذارة يكون مربحا للفلاحين الصغاروالمتوسطين لأنها تقتصد البذور(مابين 50 و60 كيلوغرام بالنسبة للقمح والشعير) وغالبا ما تمكن من مردودية جيدة. أظهرت الدراسة الإقتصادية للبذارة أنه ينبغي استعمالها على الأقل في 4.6 هكتارات سنويا حتى يكون استثمارالفلاح مبررا.

REFERENCES BIBLIOGRAPHIQUES

BANSAL, R. K. , EL GHARRAS O. and HAMILTON J. H. 1989. A roller type positive feed mechanism for seed metering. J. Agr Eng Research. 43: 23-31.

BOUAZIZ, A. and BRUCKLER L. 1989. Modeling of wheat imbibition and germination as influenced by soil properties. Soil Sci. Soc. Am. J. 53 : 219-227.

BOUGHLALA, M. , LAARMMARI A., and RAFSNIDER G. T. 1989. Enterprise Budgets for Chickpeas, Faba Beans, Lentils, and Peas produced on medium sized farms in the Chaouia Region of Settat Province, Morocco during the 1987-88 cropping year. Agricultural Economics Bulletin No. 12. Centre Regional de la Recherche Agronomique, BP 290 Settat, Morocco. 16pp.

BOUTFIRASS, M. 1986. Method and rates of seeding of durham wheat in arid and Semi-arid regions. Annual Research Report 1985-86. Centre Regional de la Research Agronomique, BP 290, Settat, Morocco : 156-158 (Limited distribution)

MARA 1987. Etude sur les subventions à l'équipement des exploitations. Vol. 1. 106 p. Available from MARA, Rabat, Morocco.

RAFSNIDER, G. T. , A. LAAMARI and M. BOUGHLALA. 1990a. Large, medium, and small farm family resources and crop revenues in Chaouia Region of Settatt Province, Morocco during the 1987-88 cropping year. Agricultural Economique, BP 290, Settat, Morocco. 13 pp.

RAFSNIDER, G. T. and LAAMARI A. 1990b. Large, medium, and small farm family resources and crop revenues in Abda Region of Safi Province, Morocco during the 1985-86 cropping year. Agricultural Economics Bulletin Number 8, Revised. Centre Regional de la Research Agronomique, BP 290, Settat, Morocco. 13 pp.

ROTZ, C. A. 1987. A standard model for repair costs of agricultural machinery. Applied Engineering in Agriculture. Vol. 3, No. 1 : 3-9.