# ECONOMICS OF AERIAL SPRAYING ON COTTON IN EGYPT

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## *Abstract*

The cost of aerial application was greatly affected by the number of operations executed annually and the level of utilization (flying hours/ operation). Such conclusion stemmed from the generalized assumption that emerged in 1990 to spray the whole cotton area using either fixed-wing planes represented by Kruk (PZL - 106 AS) or helicopter represented by (Mi - 2).

105 and 141 % increase in cost were recorded for multi-operations / year and single operation / year by means of Kruk and (Mi-2) , respectively - at 50 flying hours . At the actual level (117 hrs.109 hrs), the increase was 65% and 104%. At 500 flying hours, 20% and 39% were recorded. However, the majority of local operators could be classified under the category of single-operation per year.

Concerning the volume of ag-aviation activity, the sprayed area was subject to successive reduction during 1987/1991 due to change in strategy of application by the Ministry of Agriculture. The circular - protective spraying of the whole cotton area was replaced by a selective spraying of only the infested plots, thus returning back to ground equipment after certain degree of modernization.

The calculated percentage of reduction in ag-aviation utilization ranged between 50% to 89% for all governorates with an average of 70% for the whole country.

## INTRODUCTION

The Egyptian cotton yield represents 3.7 % of the world production of cotton, where the area cultivated is about 17% of the total area, and its production represents 70% of the agricultural exported materials. (Anonymous 1987).

National operators of aerial spraying are nowadays suffering from the successive increase of costs, for the offered prices of this service do not match the level of cost increase, a matter that was reflected negatively on the progress of this service in Egypt (Elhakim 1992) . From the economical point of view, it is important to put some emphasis on the actual costs of aerial service directed to cotton insect control using fixed-wing planes and helicopters. The results of the economic study might assist both users and operators to understand better the benefits of such sevice, thus reactivating it for the sake of the national economy . The present work evaluates the recent economics of ag-aviation in Egypt. Actual costs of aerial operations were calculated at various levels of utilization, with a special reference to the cost of certain modern ground equipment for comparison.

## MATERIALS AND METHODS

### 1 . Costs and revenue of spraying cotton applications

#### 1.1 . Cost of aerial spraying

The actual costs of spraying application during the season 1991 were collected and calculated as shown in Table 1. The seasonal cost of application prices of fixed-wing plane (Kruk) and (Mi -2) helicopter were estimated at several levels if seasonal and annual utilization ranged between 50-500 flying hours .(Tables 2 A,B). 18% interest was considered as the dominant rate accepted by the commercial banks during 1991, with no additional margin of profit. The profitable price was estimated after reduction of 3% tax fee.

#### 1.2 . Revenue of aerial spraying services

Table 3 presents the actual prices paid by the user (Ministry of Agriculture) to the oprators during 1971-1991. Prices were expressed in US-dollar because the

Table 1. Cost of aerial spraying of the whole cotton area (320 thousand fed.) by means of fixed-wing planes or helicopters during 1991 season.

| | | | |
|---|---|---|---|
| Productivity, fed./h | 215 | 170 | mean practical value (LV application) |
| Rate of performance, fed /day | 950 | 700 | mean practical value(LV appliation) lone pilot |
| No. active aircraft | 34 | 46 | spray cycle = 10 days |
| No. reserve aircraft | 8 | 11 | 25% of active fleet |
| Total fleet of aircraft | 42 | 57 | |
| No. of spray cycles | 3 | 3 | actual figure in 1991 season |
| Total sprayed area, fed | 960000 | 960000 | Basic area = 320000 Fed. |
| No. operational flying hours. | 4465 | 5647 | per season (Total area/ productivity) |
| No. ferrying hours | 447 | 564.7 | 10 % of operational hours |
| Total flying hours | 4912 | 6212 | per season |
| flying hours /aircraft | 116.95 | 108.98 | per season |
| Fuel consumption, lit/h | 165(3) | 280(4) | (3) fuel 100 LL ; (4) Fuel Jet Al |
| Cost of fuel & oil, LE/h | 230 | 200 | |
| No. working centers/airstrips | 4/40 | 4/55 | distributed in 12 governorates |
| **Seasonal fixed cost (5) , LE** | | | 4 months / each aircraft |
| A/c depreciation(6) | 10656 | 31080 | (8%) +3 |
| A/c Insurance (6) | 13320 | 38850 | (Hull & TPL 10%) |
| Depreciation of equipment | 920 | 920 | ((20%) + 3) 15 Bar./Pump. equip. = A/Cx20% |
| Head office & Administration | 1619 | 1193 | per one aircraft |
| Total fixed cost per A/C | 26515 | 72043 | per flying hour |
| Total fixed cost /hour | 226.72 | 661.07 | |
| **Variable cost , LE/h:** | | | |
| Crew allowances (6) | 100.00 | 183.15 | including full accomodation & insurance |
| A/C spare parts | 31.96 | 93.24 | including custom fees (0.3% of Depreciation) |
| Means of Transportation | 36.00 | 48.00 | Hired Locally |
| Ag. workers & guards | 43.80 | 58.40 | Including Cost of protective clothes & Insurance. |
| Fuel & oil Aircraft | 255.0 | 210.0 | including transport. Installation/governorates |
| Reserve, 2% | 9.33 | 11.83 | minimum |
| TOTAL | 476.13 | 604.60 | |
| Total net Cost, LE/h | 702.82 | 1265.72 | fixed & variable costs |
| Net cost , LE /fed | 3.27 | 7.45 | |
| Price , LE / fed | 3.86 | 8.79 | With a marginal profit : 18%, for three guaranteed sprays |
| Offered price, LE/fed | 3.98 | 9.06 | Including 3% Taxes |

(1) A/C price = $ 120000, (2) hel. Price = $ 350000 (5) Rate of exchange 1 USD = LE 3.33 (6) In ($) Bank rate of interest ( 1991) 18%

Table 2A. Estimated prices * of LV aerial spraying using a fixed-wing plane kruk (PZL-106AS), in Egyptian pounds, during 1991, at several levels of utilization.

| Utilization (4) flying hours per plane | Cost of multi - operation/year | | | | | Cost of single - operation/year | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | fixed -(1) cost | Variable cost LE/h | Net -(2) cost | Profit -(3) + 18% | price LE/fed +3%a tax- | Fixed cost LE/Year | Variable cost LE/h | Net -(2) cost | Profit -(3) + 18% | price LE/fed +3%a tax- |
| 50 | 26515 | 476.1 | 4.68 | 5.52 | 5.69 | 7545 | 476.1 | 9.61 | 11.34 | 11.69 |
| 100 | 26515 | 476.1 | 3.45 | 4.07 | 4.19 | 7545 | 476.1 | 5.91 | 6.98 | 7.20 |
| 116.95 | 26515 | 476.1 | 3.26 | 3.86 | 3.98 | 7545 | 476.1 | 5.38 | 6.35 | 6.54 |
| 150 | 26515 | 476.1 | 3.04 | 3.58 | 3.69 | 7545 | 476.1 | 4.68 | 5.52 | 5.69 |
| 200 | 26515 | 476.1 | 2.83 | 3.34 | 3.44 | 7545 | 476.1 | 4.06 | 4.80 | 4.64 |
| 250 | 26515 | 476.1 | 2.71 | 3.20 | 3.29 | 7545 | 476.1 | 3.69 | 4.36 | 4.23 |
| 300 | 26515 | 476.1 | 2.63 | 3.10 | 3.19 | 7545 | 476.1 | 3.45 | 4.07 | 3.95 |
| 350 | 26515 | 476.1 | 2.57 | 3.03 | 3.12 | 7545 | 476.1 | 3.27 | 3.86 | 3.98 |
| 400 | 26515 | 476.1 | 2.52 | 2.98 | 3.07 | 7545 | 476.1 | 3.14 | 3.70 | 3.82 |
| 450 | 26515 | 476.1 | 2.49 | 2.94 | 3.03 | 7545 | 476.1 | 3.04 | 3.58 | 3.69 |
| 500 | 26515 | 476.1 | 2.46 | 2.90 | 2.99 | 7545 | 476.1 | 2.95 | 3.49 | 3.59 |

(1) season = 1/3 year, (2) plus 25% reserve (3) Average bank rate of interest, (4) Productivity & rate of performanc= 215 fed/h & 950 fed./day, (*) Based on data of Table 3.

Table 2 B . Estimated prices * of LV aerial spraying using a helicopter (Mi - 2), in Egyptian pounds, during 1991, at several levels of utilization.

| Utilization (4) flying hours per plane | Cost of multi - operation/year | | | | | Cost of single - operation/year | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | fixed cost (1) | Variable cost LE/h | Net cost (2) | Profit (3) + 18% | price LE/fed +3% taxes | Fixed cost LE/Year | Variable cost LE/h | Net cost (2) | Profit (3) + 18% | price LE/fed +3%a tax- |
| 50 | 72043 | 604.6 | 12.03 | 14.20 | 14.64 | 216129 | 604.6 | 28.98 | 34.20 | 35.26 |
| 100 | 72043 | 604.6 | 7.79 | 9.20 | 9.48 | 216129 | 604.6 | 16.27 | 19.20 | 19.79 |
| 108.98 | 72043 | 604.6 | 7.45 | 8.79 | 9.06 | 216129 | 604.6 | 15.22 | 17.96 | 18.52 |
| 150 | 72043 | 604.6 | 6.38 | 7.53 | 7.76 | 216129 | 604.6 | 12.03 | 14.20 | 14.64 |
| 200 | 72043 | 604.6 | 5.68 | 6.70 | 6.90 | 216129 | 604.6 | 9.91 | 11.70 | 12.06 |
| 250 | 72043 | 604.6 | 5.25 | 6.20 | 6.39 | 216129 | 604.6 | 8.64 | 10.20 | 10.51 |
| 300 | 72043 | 604.6 | 4.97 | 8.56 | 6.05 | 216129 | 604.6 | 7.79 | 9.20 | 9.48 |
| 350 | 72043 | 604.6 | 4.77 | 5.63 | 5.80 | 216129 | 604.6 | 7.19 | 8.48 | 8.75 |
| 400 | 72043 | 604.6 | 4.62 | 5.45 | 5.62 | 216129 | 604.6 | 6.74 | 7.95 | 8.19 |
| 450 | 72043 | 604.6 | 4.50 | 5.31 | 5.47 | 216129 | 604.6 | 6.38 | 7.53 | 7.76 |
| 500 | 72043 | 604.6 | 4.40 | 5.20 | 5.36 | 216129 | 604.6 | 6.10 | 7.20 | 7.42 |

(1) season = 1/3 year, (2) plus 25% reserve (3) Average bank rate of interest, (4) Productivity & rate of performanc= 215 fed/h & 950 fed./day, (*) Based on data of Table 3.

Table 3 . The approximate prices and payment conditions of aerial spraying of cotton , as paid by the Ministry of Agriculture to foreign & local operators during 1971 - 1991.

| (1) Year/s | Operator | | Basic(2) cotton Area $10^3$ (fed) | Operator | | Rate(3) of Exchange (L.E.) | price USD /fed | | % (4) Paid in USD | Number of spray cycles |
|---|---|---|---|---|---|---|---|---|---|---|
| | Foreign | Local | | Fixed wing (fw) | Hel. (hel) | | Fixed wing (fw) | Hel. (hel) | | |
| 1971 | + | | 750 | 0.358 | - | 0.395 | 0.91 | - | 75 | 3.0 |
| 1972 | + | | 850 | 0.433 | - | 0.395 | 1.10 | - | 75 | 2.5 |
| 1973 | + | | 1150 | 0.402 | - | 0.395 | 1.02 | - | 75 | 3.0 |
| 1974 | + | | 1150 | 0.402 | - | 0.3950 | 1.02 | - | 75 | 3.1 |
| 1975 | + | | 1150 | 0.415 | - | .395 | 1.05 | - | 75 | 2.7 |
| 1976 | + | | 850 | 0.565 | - | 0.395 | 1.43 | - | 75 | 3.2 |
| 1977 | + | | 995 | 1.045 | 1.130 | 0.707 | 1.47 | 1.60 | 75 | 3.3 |
| 1978 | + | | 850 | 1.100 | 2.474 | 0.707 | 1.56 | 3.50 | 75 | 3.7 |
| 1979 | + | + | 330 | 1.310 | 2.370 | 0.707 | 1.85 | 3.35 | 80 | 3.3 |
| 1979/81 | + | | 526 | 1.414 | - | 0.707 | 2.00 | - | 80 | 3.9 |
| 1980/82 | + | + | 410 | 1.414 | - | 0.707 | 2.00 | - | 70 | 4.0 |
| 1982/84 | + | + | 447 | 4.414 | 2.439 | 0.707 | 2.00 | 3.45 | 70 | 4.2 |
| 1983/85 | | + | 307 | 1.581 | - | 0.832 | 1.90 | - | 60 | 4.1 |
| 1985/87 | | + | 561 | 2.160 | 3.400 | 1.2726 | 1.70 | 2.67 | 40 | 4.1 |
| 1986/88 | | + | 322 | 2.160 | - | 1.2726 | 1.70 | - | 40 | 4.2 |
| 1988/90 | | + | 400 | 3.150 | 4.300 | 1.860 | 1.70 | 2.31 | 35 | 3.6 |
| 1989/91 | | + | 364fw | 3.900 | - | 2.90 | 1.35 | - | 35 | 3.0 |
| 1990 | | + | 200hel | | 4.35 | 2.90 | - | 2.53 | 00 | 3.0 |
| 1991 | | + | 320hel | | 9.00 | 3.33 | - | 2.70 | 00 | 3.0 |

(1) one year contrct or three years contract
(2) Cotton area specified for aerial application
(3) official rate announced by the central bank of Egypt (for one USD).
(4) prortion paid by the Ministry to face foreign expenses.

biggest portion of cost components (i.e.) depreciation , spares, hull, insurance, crew, overhaul, ... etc). were spent in foreign currency.

The main sources of the tabulated data were the archivium of the Egyptian ag-aviation companies, Negm (1983) , Elhakim (1992) , Gabir (1975 - 92) and Gabir (1991); in addition to personal communications with the Department of Locust Affairs and Agro-aviation, Ministry of Agriculture and Department of Plant Protection, Faculty of Agriculture, Ain Shams University.

### 1.3 . Cost and production of certain ground equipment

In order to compare the cost of aerial spraying with the cost of ground application, seven conventional and new (under test) ground spraying equipment were investigated during the insecticide spraying programme of cotton. Daily rates of performance and costs of operation were estimated and recorded in Table 4 . Techno-operational data of the mentioned spraying techniques were preseneted also in the same table.

## RESULTS AND DISCUSSION

Tables 1 and 3 present the cost and revenue of the aerial spraying operations of cotton during 1991 season. The component forming the actual cost of low volume aerial services either by Kruk plane or by Mi-2 helicopter for the whole cotton area are presented as an actual example. Seasonal fixed-costs were calculated on basis of multi-operations per year at the practical levels and limitations encountered in Egypt. Total fixed cost was estimated per each flying hour of single aircraft from the used fleet. The total net cost using Kruk and (Mi - 2) helicopter was 3.27 and 7.45 L.E./Fed., respectively.

By adding a minimum marginal profit of 18% and the commercial industrial taxes of 3% the aerial services could be offered at 3.98 or 9.06 L.E. /F with same arrangement , as a minimum price with no extra margin of profit. The required percentages of foreign portion in the net cost was 48.0 and 72.5% for Kruk and Mi-2 aircraft, successively which covers the aforementioned foreign expenses.

In figures, the foreign costs per feddan were 0.47 and 1.62 US$ successively.

Table 4. Techno-operational data and cost of utilization of certain ground spraying machines used for controlling cotton insects during 1991 season

| Type & model of atomizer | Micro Ulva | Level - Operated (Diaphragm pump type Cp-20) | | | conventicanl Motor"Genar" | Motorisized Knapsack solo (stihl SG-17) | |
|---|---|---|---|---|---|---|---|
| | Rotary | Hydrulic | | | | Pneumatic | |
| | Spinning disc atomizer | Hand - Lance TXVS -6 | 02-F 110 | D5 - 45 ( original sprayer) | D 600 Spray gun | orifice No.3 air speed 70 m/sec | Out let 100m/sec |
| No. of atomizer | 1 | 3 | 3 | 1 | 2 | 1 | 1 |
| spacing; m | - | 0.60 | 0.51 | - | varous | - | - |
| Kind of spray | Drift | Drift | Target | Target | Target | Taget | Taget |
| Swath width, m | 5-0 | 5.0 | 3.0 | 1.5 | 3.0 | 5.0 | 10.0 |
| Approx. Spray height, m | 0.75 | 0.50 | 0.50 | 0.30 | 0.30 | 0.30 | 0.30 |
| Tank Capasity, Liters | 10.0 | 20.0 | 20.0 | 20.0 | 150 | 10.0 | 10.0 |
| Productivity, fed./h | 2.85 | 2.85 | 1.71 | 0.86 | 1.71 | 2.85 | 5.70 |
| Rate of performance, fed / day (at 6 working hours) | 10 | 10 | 6 | 3 | 8.0 | 10 | 20 |
| Approx. Cost, LE/fed | 1.30 | 3.65 | 3.65 | 2.67 | 9.38 | 2.0 | 1.0 |

Tables 2A and 2B show the estimated prices of low volume aerial spraying by means of fixed -wing plane and helicopter at several levels of utilization (50-500 flying hours) for a single operation /year and multi-operations/ year. Estimation of the tabulated prices was made under the general basis of calculations as mentioned in Table 1.

Two main factors which evidently affected the net cost of aerial services under the local operational conditions were the level of seasonal / annual utilization and the number of annual operations (single or multi-operations). Both factors could in the end affect the total number of flying hours utilized per annum at the level of 50 flying hours. The percentages of increase in prices between single operation and multi - operations were 105.4% and 140.9% for the fixed-wing plane and helicopter , respectively. At 500 flying hours, the percentages of increase were 20% and 39 % at same arrangement. At the traditional level of utilization, such percentages were 65.0% and 104.3% at utilization level of 116.95 and 108.98 hours/season for Kruk plane and Mi-2 helicopter, respectively (Fig.1).

On the other hand, increasing the number of flying hours from 50 up to 500 hours caused a great reduction in prices under both single and multi operations.

The revenue of aerial services during the last 20 years expressed in values paid by the user to operators are recorded in Table 3.

Due to the strong competition between local operators having aviation capacities exceeding the actual requirements of the market, the price level started to decrease (Table 3). This was reflected on their performance and later on their stability and efficiency as shown by poor and improper utilization of their owned fleet of aircraft.

Concerning the level of prices in Egyptian pounds paid during 1971-1991, an increase of 989% was realized during this period . However this increase was ostensible because about two-thirds of ag-aviation costs were spent in foreign currency. Consequently, real analysis should be based on prices expressed in foreign currency. In this case, the level of prices increased to about 120% during 1971- 1985, in addition to 60-80% of foreign currency paid to cover foreign expenses.

In general , the price was reduced by 33% during the period 1986 and 1991. This was associated with a portion of foreign currency (40%) in 1986 that reached zero percent in 1990/91.

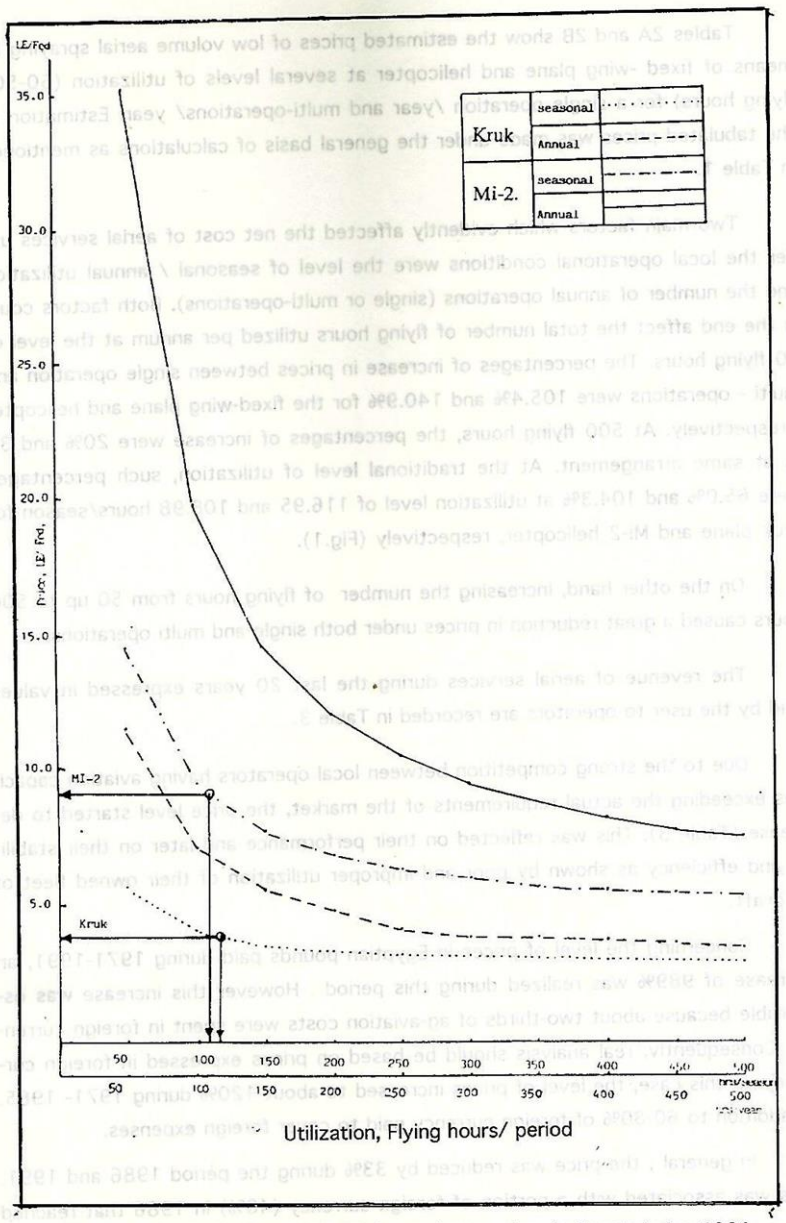


Fig. 1. Estimated price of LV aerial spraying services in Egypt during 1991

Table 4 shows the techno-operational data and cost of utilization of seven conventional , new and experimental ground spraying techniques used for controlling cotton insects during 1991 season. The rates of performance ranged between 3.00 and 20.0 feddans with an average of 9.57 feddans during six daily working hours, i.e. 1.60 f/h, which represents 0.67 % and 1.12% from the average productivity of Kruk/ Antonov and Bell/Mi-2, successively.

The operation average cost of the ground equipment techniques was L.E. 3.38/ f in comparison with an average net costs for Kruk plane and Mi-2 helicopter L.E. 3.27/f and L.E. 7.45/f, respectively. It seems that the costs of operation using ground equipment and fixed-wing plane were very close to each other and represented approximately half the helicopter's cost, regardless of the superiority of spray quality and specific bioefficacy obtained with helicopter.

## CONCLUSION

From the economical point of view, the estimated prices of low volume aerial services were 3.98 and 9.06 L.E./f by fixed-wing and Rotary aircaft, respectively without any extra margin of profit . The percentages of foreign portion in (US $) in the net costs of the aircrafts was 48.0 and 72.5% (0.74 and 1.62 US $ /f), successively. Under the local operational circumstances, the cost of aerial services was affected clearly with the level of seasonal or annual utilization and the number of operations per year. The percentages of increase in prices of low volume aerial spraying between single and multi-operations for Kruk and Mi-2 were 105 % and 141% at 50 flying hours, respectively. At the actual utilization level (117 and 109 hours), the increase was 65% and 104%, respectively. At 500 flying hours however, it was 20% and 39% at the same arrangement . The level of prices in US-dollars paid to foreign and local operators increased up to 120% from 1971 to 1985, in addition to a portion in foreign currency (60-80%) paid to them to face foreign expenses at that time. After Nationalization of agroaviation activity, the prices were reduced by 33% starting from 1986 to 1990, and no payment in foreign currency was made at all. One of the main reasons for price and payment deterioration, was the way of calculating the official rate of US $ exchange which was reduced by 300% during 1986-1990. Such reduction was born completely by local operators who worked solely during that period.

Concerning the voulume of agroaviation activity during the last five years (1987-1991) , a clear reduction in total cotton areas in all governorates was observed due to changing of the application strategy applied by the Ministry of Agriculture. The percentage of reduction ranged between 50-89% with an average of 74% . At the same period , the national fleet of aircraft owned by the Egyptian operators was decreased by more than 70% due to the reasons mentioned above.

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# إقتصاديات الرش الجوي عل محصول القطن في مصر

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تتأثر تكاليف تطبيقات الرش الجوي بشدة بعدد العمليات المنفذة سنويا ومستويات التشغيل في كل عملية ويظهر ذلك بوضوح علي فرض أنه سيتم رش مساحات القطن باستخدام الطائرات ثابتة الجناح مثل الكروك ( بيزتيل ١٠٦ ايه – اس) أو الطائرات العمودية مثل (مي –٢) تحت الظروف المحلية للتشغيل.

سجلت النسب المئوية التالية للزيادة في التكاليف السنوية بين العمليات المتعددة والعملية الواحدة بواسطة كل من الكروك، مي –٢ عند ٥٠ ساعه طيران وكانت هذه النسب ١٠٥٪ ١٤١٪ علي التوالي

كانت الزيادة في التكلفة ٢٠٪ ، ٣٩٪ عند المستوي الفعلي للتشغيل (١١٧ ساعة / ١٠٩ساعة) ، ٦٥٪، ١٠٤٪ عند ٥٠٠ ساعة طيران .

عموما يمكن أن تندرج غالبية العلميات المحلية السنوية في مصر تحت نظام العملية الواحدة، أما بخصوص حجم نشاط الطيران الزراعي ، فقد قلت كل المساحات الأساسية والاجماليه المرشوشة خلال الفترة من ١٩٨٧ – ١٩٩١ ويرجع ذلك الي التغيير في استراتيجية التطبيق المتبع في وزاره الزراعه والذي كان في اتجاهين وهما احلال الرش الاختياري للمناطق المصابه بدلا من الرش الدوري الوقائي لكل مساحات القطن ، واعاده تنشيط دور المعدات الأرضية بعد تطويرها واستخدام تقنيات حديثة تناسب عمليات مكافحة القطن ، وتراوحت نسبة الانخفاض في المساحات ما بين ٥٠٪ ، ٨٩٪ في كل المحافظات بمتوسط عام قدره ٧٠٪ علي مستوي الجمهورية.