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INFLUENCE OF TOPOGRAPHICAL FACTORS ON PRODUCTIVITY OF AGRICULTURAL AIRCRAFT IN EGYPT

ABDEL-LATEEF M.F.[1], I. GABIR[2], HINDY,[3] M.A. AND NEGM, M.F.[3]

1 Department of Plant protection, Faculty of Agriculture, Al-Azhar University.
2 Department of Plant Protection, Faculty of Agriculture, Ain-Shams University.
3. Department of spraying Technology Researches, Plant Protection Research Institute, Agricultural Research Centre, Dokki, Giza.

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Abstract

Five main factors affecting the productivity of agricultural aircraft, which are: topografical, technical, operational, climatic and pilotage-wise factors. The present work concentrated on topographical factors such as: field size, field run length, ferry flight distance and interplot ferrying distance, with the use of Mi-2 helicopter for spraying cotton plantations during 1992-93.

The run length as a function of field size proved to be the highest effective decisive factors, while the minor factor was interplot ferry. The ferry flight is situated between the mentioned two extremes, but more close to the interplot ferry.

INTRODUCTION

One of the decisive factors defining the cost of agricultural aviation operation is the aircraft productivity. The productivity is influenced positively by five main groups of factors; which are topographical, operational, technical, climatic and pilotage qualifications.

Gabir *et al.*, (1991) studied influence of the components of topographical factors (field size /run length/ferry flight/inter-plot ferrying) on the productivity of light and heavy models of fixed-wing aircraft and helicopter over Egyptian cottton cultivations at certain governorates - representing about half of the cultivated area - during end of the seventies. The mean values of the mentioned factors for Egypt were 50 fed./0.38 km/11.0 km/1.89 km, respectively.

It is proven that increasing the inter-plot ferry distance of half kilometer and the ferry flight of two kilometers by nine times decreased the aircraft productivity

by 6% and 43% and 43%, respectively, while doubling the run length of 0.3 km and 0.5 km increased the productivity by 28% and 19%, respectively.

Therefore, it seems essential to re-evaluate the influence of those factors on the aircraft productivity after fifteen years, since the previous appraisal made by Gabir *et al.*, (1991) but, more precisely on all cotton producing governorates in Egypt, with the use of Mi-2 helicopter, the only used type.

MATERIALS AND METHODS

The main techno-operational data of Mi-2 helicopter for chemical spraying of cotton are as follows: mean cruising speed (V_c) = 150 km/h; mean operational speed (V_o) = 60 km/h; chemical load (C) = 500 liters; run width (R_w) = 30 m; mean time of 180^{o}C turn (μ) = 1.00 minute; mean time of reloading of chemical (Nr) = 2.00 min., mean time of T.O & landing (Nx) = 0.2 min. Number of daily flying hour (one pilot = 4.00 hour); number of daily working hour = 6.00 hours when rate of application (T) = 10 lit./fed. and mean helicopter productivity = 125 fed./h.

Measurement of topographical factors i.e. field size, run length, ferry flight distance and interplot ferrying distance were extracted from the operational maps (1: 25000) of 220-289 areas-subject of spraying distributed on about 100 districts in twelve governorates in the cotton belt; Kaliobeya, Menofeya, Gharbeya, Bihera, Kafr El-Sheikh, Sharkeya Dakahleya (Lower Egypt), Fayoum, Beni-suef, Menya, Assuit (Middle Egypt) and Sohag (upper Egypt), during two successive cotton seasons 1992 and 1993.

The average values for Egypt of field size (k_2), run length (R_L), ferry flight (D) and interplot ferrying (K_3) were 36 fed./0.45 km/3.5 km/3.5 km,respectively.

Gabir's formula for multi-field fly over (Gabir, 1997) was applied, as the minimum cotton field size was less than the capacity of one helicopter sortie (50 feddans).

PR (fed./h) = 55.8 C/T {(C/T. Rw. $[(252/V_o) + (4200\mu/R_L) + 60\ K_3/V_c]$ + $[120\ D/v_c]$ $(N_x + N_r)$}. After fedding of the know-fixed technical and operational values of Mi-2 helicopter to this formula, the productivity (PR) was estimated by means of a more simple formula : PR (fed./h) = 3000 / $[(0.80D) + 7/R_L) + 0.40K_3)]$ + (9.20).

RESULTS AND DISCUSSION

A. Effect of topographical constants: The effect of each topographical constants on helicopter productivity in various areas, districts and governorates was analysed, discussed seperately, Table 1. Data in Table 2 show the productivity of Mi-2 helicopter estimated with the knowledge of topographical constants of Table 1 for each area served by one operational landstrip and then as an average for governorates. Studing the combination influence of factors and their interactions are complicated and was not included in the present investigation.

1. Field size: The mean number of plots (fields) sprayed was 16272 plots, with an average size of 34 feddans. A clear reduction of 32% was happened to the plot size and its related factors, i.e. number of plots and run length, from 1978 to 1993.

According to Negm (1983), the averages of basic cotton area, number of plots and field size in 1978/79 were 1.13 million feddans, 37581 plots and 50.24 feddans, respectively, which exceeds the present measurements with 52%, 59% and 32% at the same mentioned arrangement.

The Egyptian governorates could be arranged descendingly, according to the mean field size as follows:

Assuit (Sohag Menya) - Gharbeya - Kafr El-Sheikh-Beni-suef (Kaliobeya/ Dakahelya) - Bihera - (Menofeya/Sharkeya) - Fayoum.

The mean cotton area served by one landstrip was 2068 feddans and the mean number of plots of each area was 60.6.

2. Run length: With the knowledge of the mean field size of 34.14 fed. and the mean run length of 0.455 km, the average number of swaths was 11 swaths with 30 meters width.

Comparing present data with that of 1978, it seems that the greatest deterioration of topographical factors was occurred to the field run length, when a significant reduction of 46%, 36% and 43% was found in regions of Nile Delta, Middle Egypt, Upper Egypt and Egypt (in general), respectively. Therefore, the governorates could be categorized according to the field run length, in a descending way order as follows: Assuit - sohag - Menya - Gharbeya - Kafr El Skeikh - Beni-suef (Dakahleya / kaliobeya) - Menofeya - Bihera - Fayoum - Sharkeya.

Table 1.Average topographical constants of the Egyptian governorates (1992/93).

Governorate	1992				1993				1994			
	field size K_2 (fd)	Inter plot ferry K_3 (Km)	Run length R_L (km)	Ferry flight D (km)	field size K_2 (fd)	Inter plot ferry K_3 (Km)	Run length R_L (km)	Ferry flight D (km)	field size K_2 (fd)	Inter plot ferry K_3 (Km)	Run length R_L (km)	Ferry flight D (km)
Kaliobeya	24.79	3.035	0.420	3.723	24.29	2.817	0.383	3.713	24.54	2.926	0.402	3.718
Menofeya	17.09	2.010	0.377	3.350	19.27	2.450	0.400	4.140	18.18	2.230	0.389	3.745
Gharbeya	40.12	2.340	0.533	3.220	35.33	2.320	0.426	3.502	37.73	2.330	0.480	3.361
Bihera	20.35	2.890	0.374	3.880	20.90	2.190	0.351	3.660	20.63	2.540	0.362	3.770
Kafr Elsheikh	34.63	2.470	0.474	3.488	34.76	2.106	0.468	3.904	34.70	2.288	0.471	3.696
Sharkeya	20.82	3.340	0.345	3.386	15.98	3.175	0.336	3.146	18.40	2.258	0.340	3.266
Dakahleya	24.75	2.790	0.401	3.568	24.58	2.369	0.405	3.670	24.67	2.580	0.403	3.619
DELTA (L.E.)	26.08	2.696	0.417	3.516	25.01	4.489	0.395	3.676	25.55	2.593	0.406	3.596
Fayoum	--	--	--	--	--	3.364	0.352	3.419	16.40	3.364	0.352	3.419
Benisuif	36.09	2.500	0.479	3.729	29.47	1.866	0.436	3.349	32.78	2.183	0.458	3.539
Menya	49.04	2.240	0.556	3.304	44.20	2.286	0.602	3.020	46.62	2.263	0.579	3.162
Assuit	77.19	2.152	0.707	3.343	140.42	2.074	0.515	3.162	108.81	2.113	0.611	3.253
MIDDLE (E.)	54.11	2.297	0.581	3.459	57.62	2.398	0.476	3.238	51.15	2.481	0.500	3.343
Sohag	51.70	2.420	0.662	4.643	42.76	2.664	0.558	3.346	47.23	2.597	0.610	3.995
Upper (E.)	51.70	2.420	0.662	4.643	42.76	2.664	0.558	3.346	47.23	2.597	0.610	3.995
Middle & (U.E)	53.50	2.328	0.601	3.755	54.65	2.451	0.492	3.259	50.37	2.504	0.522	3.473
Egypt	36.05	2.562	0.484	3.603	37.36	2.473	0.424	3.503	35.89	2.556	0.454	3.545

L.E. = Lower Egypt U.E. = Upper Egypt. E. = Egypt

Table 2.The productivity of Mi-2 helicopter estimated during 1992 and 1993 seasons.

Governorate	Productivity fed. /h			Increase / Decrease (%)
	1992	1993	Average 92/93	
Kaliobeya	99.30	94.55	96.92	-4.78
Menofeya	94.10	98.89	96.50	+5.09
Gharbeya	114.95	98.51	106.73	-14.30
Bihera	92.62	90.24	91.42	-2.56
Kafr Elsheikh	110.05	105.20	107.63	-4.40
Sharkeya	90.74	87.14	88.94	-2.86
Dakahleya	95.85	100.00	97.93	+4.32
DELTA	99.65	96.36	98.00	-3.30
Lower Egypt				
Fayoum	--	89.68	89.68	--
Beni-suef	105.29	102.19	103.74	-2.94
Menya	116.66	113.58	115.12	-2.64
Assuit	131.33	110.96	121.15	-15.51
Middle Egypt	117.76	104.10	107.42	-11.60
Sohag	122.77	116.10	119.44	-5.43
Upper Egypt	122.77	116.10	119.44	-5.43
Middle & Upper Egypt	119.09	106.50	109.83	-10.51
Egypt	106.70	100.59	102.93	- 5.73

3. Ferry flight distance: The distance of ferry flight was ranged between 3.020 km and 4.643 km in both seasons, with an averages of 3.596, 3.473 and 3.545 km in Delta, Middle and Upper Egypt and Egypt, successively. This result agreed within norm of ag-aviation operations by means of helicopter, as mentioned by Marten (1965) and Borodzik (1969), as well as with the instructions of the main user of helicopter (Ministry of Agriculture) defining the maximum ferry flight distance, for helicopter use, with five kilometers. Here in after, names of 14 districts, in which ferry flight distance exceeded the margin of five kilometers: Menuf (Menofeya) - Basyoun (Gharbeya) - Shubrakhit, Kafr Eleldawar, Damanhour and El-delingat (Bihera), Desuk (Kafr Elsheikh)- Awlad Sakr (Sharkeya)- Sherbin and Meniet Elnasr (Dakahleya) - Elmenya (Menya) - Elbadary (Asuit) - Sakulta and Elmonshaah (Sohag).

4. Interplot ferry distance: The interplot ferry distance was ranged between 2.1 - 3.4 kilometers, with an average of 2.55 kilometeres for Egypt. It is worthy to note that the mean of interplot ferry distances represented 73% of the total ferry distance. The governorates could be arranged from the shorter to the longer interplot ferry into three groups, as follows:

2.1-2.3. Km: Assuit - Beni Suif - Menofeya - Menya - Kafr ElSheikh-Gharbeya.

2.5-2.6 km: Bihera - Dakahleya - Sohag.

2.9-3.4 km: Kaliobeya-Sharkeya - Fayoum.

A significant increase of 41%, 22% and 34%, was generally recorded between the present data and that of 1978, in Nile Delta, Upper Egypt and Egypt, with a single exceptional decrease of 25% at Dakahleya Governorate.

B. Producdivity of Mi-2 helicopter: The productivity of Mi-2 helicopter was estimated and presented in Table 2, on basis of the fixed technical and operational factors and topographical constant, Results can be discussed as follows:

1. The mean productivity in Upper Egypt was higher than Nile Delta with 12%, which means that the Delta topographical conditions were deteriorated with same level within 1978-1992/93 period which affected negatively helicopter productivity.

2. A drastic reduction of 23%, 17% and 20% in productivity was calculated between 1978 and 1992/93 data, for Delta, Middle and Upper Egypt and Egypt, respectively. Such reduction in productivity means that more helicopters to be op-

erated in order to keep the same rate of performance in a given spray cycle, which means consequently and proportionally more cost of operation.

3. The governorates could be arranged ascendingly on basis of the estimated average productivity of (1992/93) in four levels, as follows:

- Very - low productive governorates: With a productivity (less than 95 fed./h) : Sharkeya-Fayoum - Behira Governorates.

- Low - productive governorates (95-110 fed./h): Menofeya Kaliobeya - Dakahleya - Beni-Suef - Gharbeya - Kafr Elsheikh Gogvernorate.

-Moderately- productive governorates (110-135-fed./h): Menya Sohag - Assuit Governorates

- High - productive governorates: with productivity more than 135 fed./h, such as Assuit Governorate in 1992 season only.

In conclusion, it can be said that the major decisive topographical factor affecting helicopter productivity was the run lengh as a function of field size and the minor factor was the interplot ferry, whereas the ferry flight distance was situated in between those two extremes, but more close to the interplot ferry.

This agreed with findings of Borodzik (1969) in Poland, where productivity was increased by 20-50% shortening ferry distance down to 50%. In Egypt, productivity was improved clearly with about 30% by reducing ferry distance from 18 to 2 kilometers or doubling the run length up to 0.6 kilometer (Negm, 1983).

On the other side, the results contradicated with that declared by Rowinski (1986), as he didn't give such significant intention to the role played by the run length factor on aircraft productivity in Poland.

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تأثير العوامل الطبوغرافية علي انتاجية الطائرات الزراعية في مصر

محمود فتح الله عبد اللطيف١ ، إبراهيم جابر٢ ،

محمد عبد العزيز هندي٣، محمد فاروق نجم

١ قسم وقاية النبات – كلية الزراعة – جامعة الأزهر – القاهرة.

٢ قسم وقاية النبات – كلية الزراعة – جامعة عين شمس – القاهرة.

٣ قسم بحوث تكنولوجيا الرش – معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقي – الجيزة.

تتأثر إنتاجية الطائرات الزراعية بخمسة عوامل رئيسية وهي عوامل طبوغرافية وفنية وعوامل تشغيل الطائرات (العمليات) والظروف الجوية وخبرة وحكمة الطيار.

يتركز ذلك العمل علي دراسة العوامل الطبوغرافية مثل مساحة الحقل (التجميعة) طول مجر الرش لكل حقل – مسافة الطيران الفاضي بين الحقول – مسافة الطيران الفاضي بين مهبط التشغيل التقليدي وهذه الحقول ثم حساب انتاجية الطائرة الهليوكبتر (طراز مي – ٢ / الطراز الوحيد المستخدم في مصر) والتي قامت برش تجميعات القطن خلال موسمي ١٩٩٢ ، ١٩٩٣.

لقد وجد أن العامل الطبوغرافي المحدد بشدة لإنتاجية طائرة الهليوكبتر هو طول مجر الرش – كدالة لمساحة الحقل – كما أن عامل مسافة الطيران الفاضي بين التجميعات يعتبر أقل العوامل تأثيرا بينما يقع عامل الطيران الفاضي بين المهبط والحقول بين هذين العاملين إلا أنه أكثر تجاوراً مع عامل الطيران الفاضي بين التجميعات.