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RYE-GRASS SEEDS AERODYNAMIC PROPERTIES VS SEED WEIGHT AND DIMENSIONS

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A b s t r a c t: Rye-grass (Lolium multiflorum var. westerwalidicum) is one of the basic seed grass varieties. Investigation on physical features of seeds, especially geometrical and aerodynamical properties follows adaptation of combine-harvester to grass harvesting. Geometrical properties (length, width) was measured by optical apparatus, which gave 29.7-fold enlargment of perpendicular projection of investigated seed. The biggest area of the projection was measured as lifting surface. Length and width of seed were from the contour of lifting surface. Aerodynamical properties was measured by apparatus, which construction made possible a fluent regulation of air stream velocity. Relative wind coefficient arise from critical velocity. All quantities were presented as statistical distribution, furthermore aerodynamical properties: critical velocity, resistance coefficient and relative wind coefficient were presented in function of mass and dimensions of seed.

K e y w o r d s: rye-grass seeds, aerodynamic properties, seed mass, seed geometry

INTRODUCTION

Rye-grass is one of basic grass species being grown for seeds. Thorough knowledge of all plant properties particularly relating to plant-machine system [2,12], is necessary to assure proper seeds production [3,5,9,11]. Detailed study and description of physical properties is extremely difficult and complex, due to specific structure and significant variability of plant materials. Therefore only few [13,14] have reported on some properties of seed grass species.

There are many physical properties to be determined, e.g. aerodynamic properties, particularly when associated with geometry [1,4,6-8,10]. Most important aerodynamic properties are: critical speed v_k, drag coefficient k_x and fineness ratio k_0. All these properties have been calculated for rye-grass.

INVESTIGATION PROCEDURES

Material under investigation

Husked air-dry seeds of rye-grass *(Lolium multiflorum Lam*, var. *westerwalidicum*) have been investigated. Sample size was 50 pcs.

Measuring apparatus

Seeds geometry parameters (lifting surface *S*, length *c*, and width *b*) have been determined by means of optical equipment (Fig. 1) providing magnified orthogonal projection

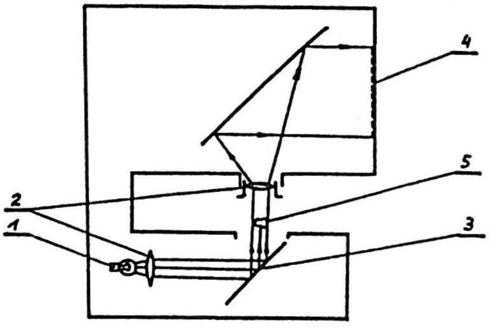

Fig. 1. Optical system of the device for determination of the grass seeds geometrical features: 1 - light sources, 2 - set of lenses, 3 - set of flat mirrors, 4 - screen with scale, 5 - seed.

(29.7 times) of the seed located inside. Generated seed contour (magnified 29.7 times) is measured with very high accuracy to find seed length and width and then lifting surface. Seed mass has been determined by means of laboratory scales within 0.01 mg.

Aerodynamic properties were determined with the use of measurement equipment (Fig. 2) providing smooth adjustment of vertical airflow.

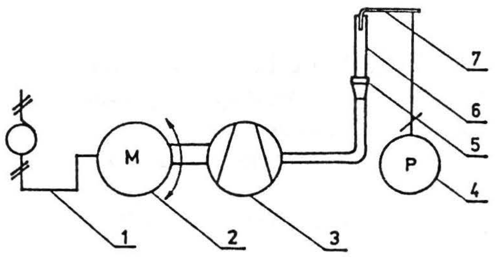

Fig. 2. Scheme of the stand for determination of the grass seeds aerodynamic properties: 1 - autotransformer, 2 - electric motor, 3 - fan, 4 - compensating micromanometer, 5 - charging mechanism, 6 - glass tube, 7 - Pitott tube.

A seed hovering in such airflow is maintained in equilibrium with airstream velocity corresponding to critical speed of the seed being investigated [10].

Calculation of aerodynamic coefficients

Critical speed v_k:

$$v_k = \left(\frac{2}{\rho} p_{dyn} \, g \right)^{1/2}, \quad (1)$$

drag coefficient k_x:

$$k_x = \frac{m\, g}{S\, v_k\, \rho}, \quad (2)$$

fineness ratio k_0:

$$k_0 = \frac{g}{v_k^2}, \quad (3)$$

carrying ratio k_n:

$$k_n = \frac{m}{S} \quad (4)$$

where ρ - air density (kg/m^3), g - acceleration of gravity (m/s^2), m - seed mass (kg), p_{dyn} - dynamic pressure in measurement tube (Pa), S - lifting surface (m^2).

RESULTS

Refer to Table 1 for basic geometry and aerodynamic properties of rye-grass seeds. For seeds sample, weight range of single seed was wide, i.e., from m=1.35 mg to m=6.35 mg with 44 % of seeds included in range from m=3 mg to m=4 mg (with average m=3,21 mg).

Critical speed values are affected by such seed mass distribution (Fig. 3). Calculated relationship between these both values is represented by exponential curve (Fig. 4a) i.e., v_k=3.45404 m$^{0.2315}$ with critical speed increasing for seed mass increase. Inversely, carrying coefficient k_0 becomes reduced for seed mass increase (Fig. 4b). This relationship is represented by exponential curve k_0=0.81563 m$^{-0.43472}$. Unfortunately, relationship of drag coefficient vs mass cannot be represented with sufficient accuracy (although insignificant decreasing trend could be noted during investigation). It could be that such important magnitude as lifting surface (Fig. 5a) should be correlated with basic aerodynamic factors, but it was impossible to be stated univocally. Critical speed increases together with lifting surface increase (but this relationship is affected mainly by close association between lifting surface and seed mass) and coefficients k_0 and k_x are reduced. Lifting surface of S=3.85mm^2 to S=10.88 mm^2 (average S= 6.88 mm^2) is reached for rye-grass seeds and increases rather rapidly for mass increase resulting in above mentioned relationship.

Lengths of seeds c are ranged from 4.24 to 7.74 mm (Fig. 5b) without any effect on their aerodynamic properties being directly not affected by seed width b (ranging from 1.19 to 1.99 mm). However, it can be undoubtly stated that for greater seed mass, seed width increases more rapidly (Fig. 5c). Owing to such undetermined effects of seed

Table 1. Basic geometry and aerodynamic properties of rye-grass seeds

Seed properties	Symbol	Unit	Value			Standard deviation
			Average	Max.	Min.	
Mass	m	mg	3.21	6.35	1.35	0.095
Length	c	mm	5.82	7.74	4.24	0.82
Width	b	mm	1.54	1.99	1.19	0.17
Lifting surface	S	mm^2	6.88	10.88	3.85	1.45
Critical speed	v_k	m/s	4.49	5.28	3.22	0.48
Drag coefficient	k_x	-	0.3745	0.5288	0.1767	0.0764
Fineness coefficient	k_0	1/m	0.5056	0.9461	0.3519	0.1228
Carrying coefficient	k_n	mg/mm^2	0.4695	0.8172	0.2284	0.1112

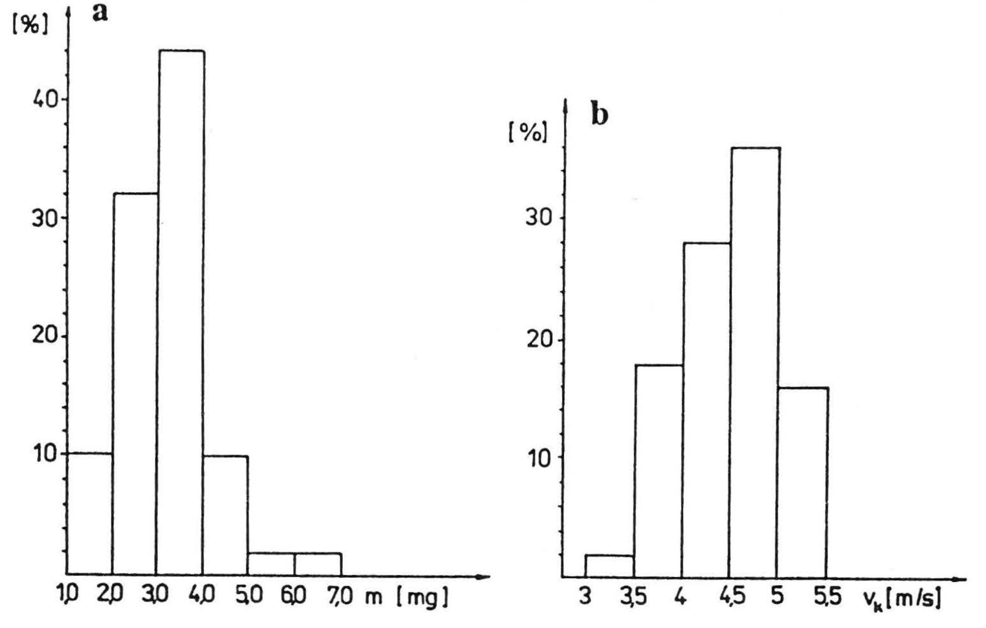

Fig. 3. Distribution of mass (a) and critical speed (b) for the rye-grass seeds.

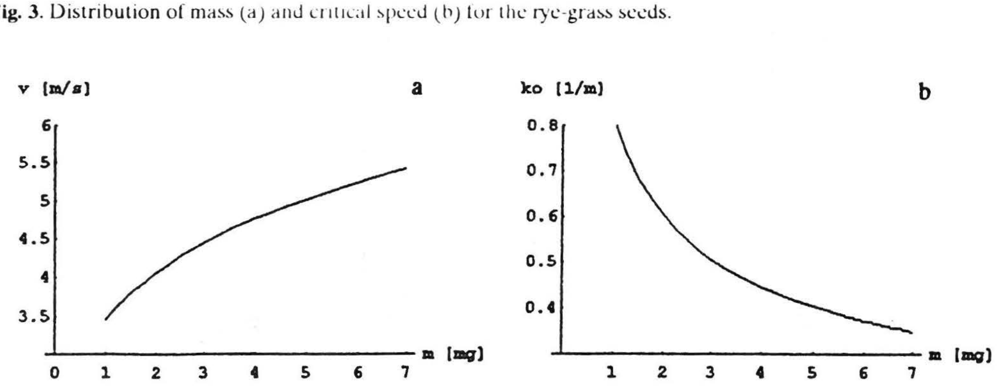

Fig. 4. Critical speed (a) and carrying coefficient (b) of the rye-grass seeds vs its weight ($vk= 3.45404\ m^{0.2315}$, $k_0=0.81563\ m^{-0.43472}$).

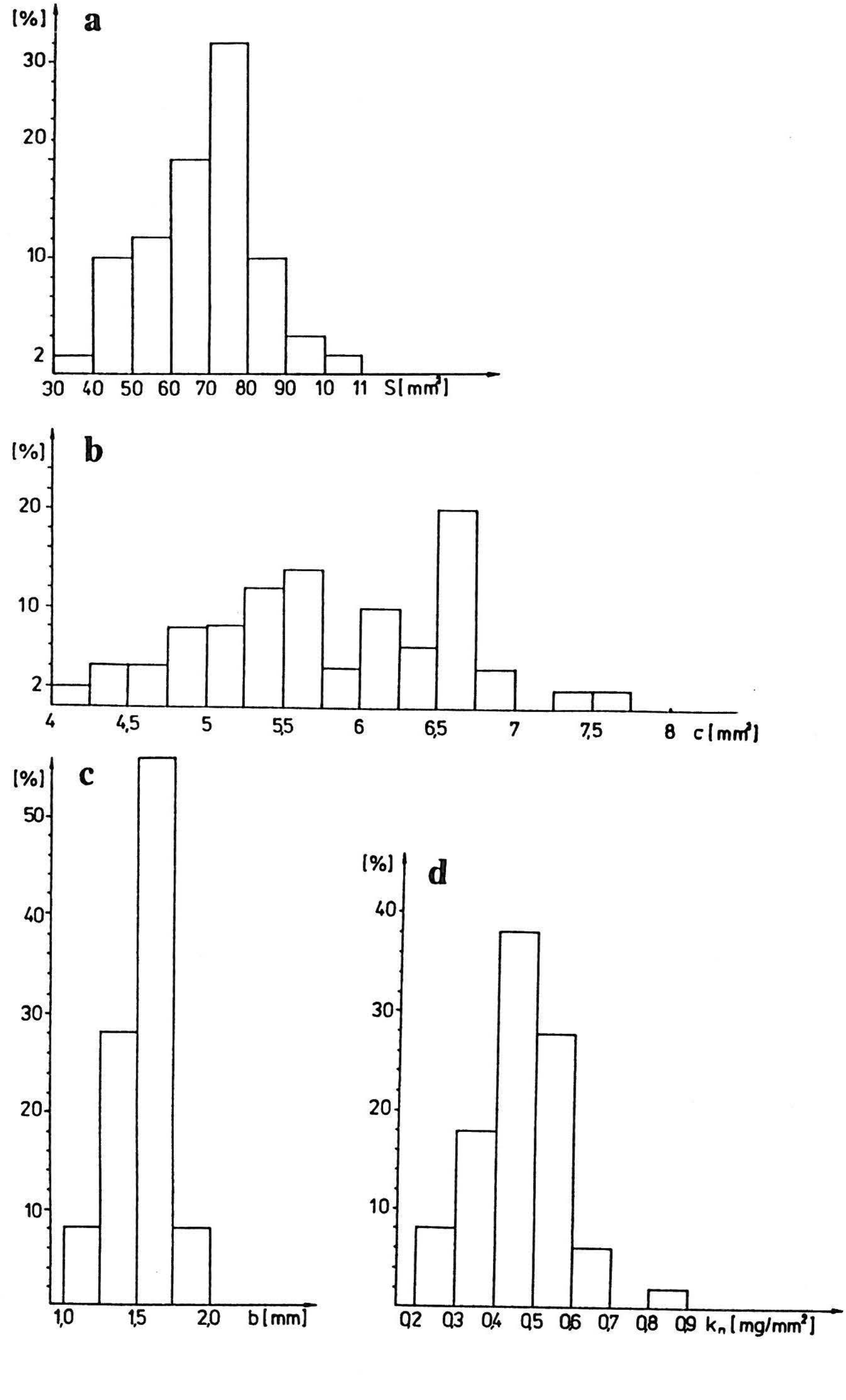

Fig. 5. Distribution of the lifting surface (a), length (b), width (c) and lifting coefficient (d) of the rye-grass seeds.

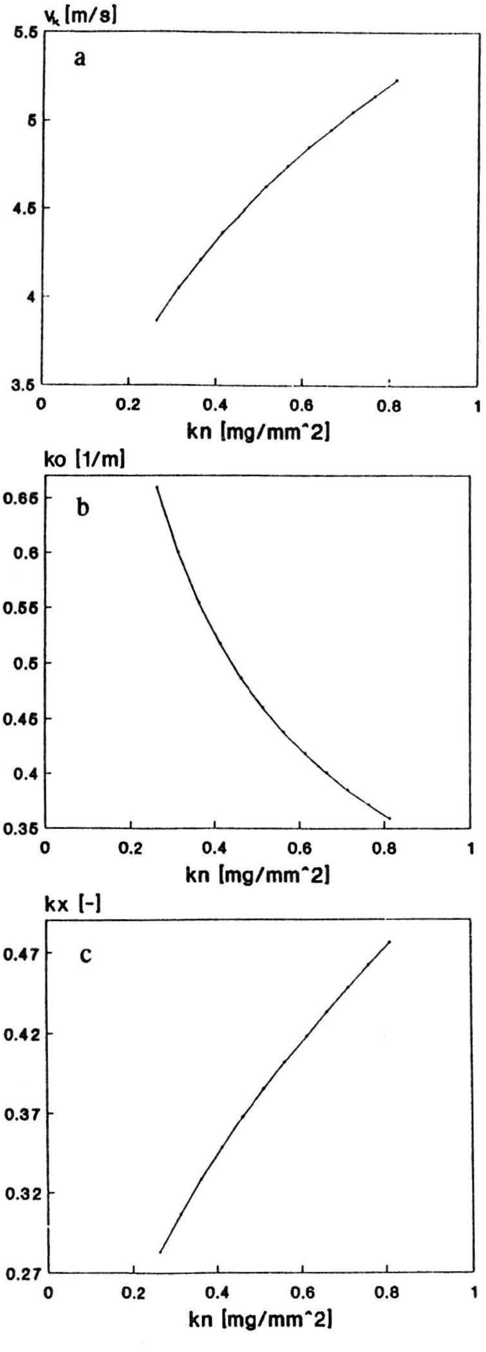

Fig. 6. Critical speed (a), fineness ratio (b), and drag coefficient (c) of the rye-grass seeds vs carring ratio.

geometry, an additional coefficient affecting greatly aerodynamic properties, has been introduced and defined as carrying coefficient k_n (Fig. 5d) to provide mass and lifting surface relationship (resulting indirect length and width association) as shown in Fig. 6 $(v_k(k_n)=e^{1.71}k_n^{0.269}, k_0(k_n)=e^{-1.137}k_n^{-0.539}, k_x(k_n)=e^{-0.648}k_n^{0.461})$.

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