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AERODYNAMIC PROPERTIES OF WEED SEEDS

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A b s t r a c t. In order to collect weed seeds while harvesting with a combine it is necessary to know their aerodynamic properties, because separation of grain and chaff in a combine is mainly done by air. Terminal velocities or other aerodynamic characteristics of weed seeds are rarely tested and little found in literature.

Twenty different weed seeds were tested. Terminal velocities were determined with an Automatic Test Stand. Tested were seeds, which are important in European grain-cultivating. The seeds are from: Alopecurus myosuroides, Apera spica-venti, Avena fatua, Atriplex patula, Capsella bursa-pastoris, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Galeopsis tetrahit, Galium aparine, Lamium purpureum, Matricaria recutita, Myostis arvensis, Polygonum convolvulus, Rumex crispus, Sinapis arvensis, Sonchus asper, Stellaria media, Thlaspi arvense, Veronica persica, Viola arvensis. Of some seeds terminal velocities were tested at different moisture contents.

K e y w o r d s: weed seeds, aerodynamic properties

INTRODUCTION

Growing cereals in Europe means using herbicides to control weeds. In order to use less pesticides it is necessary to reduce the number of weed seeds in the seed-bank of the soil [2]. In order to collect weed seeds while harvesting with a combine it is necessary to know their aerodynamic properties.

The aim of this study was to get more information about the physical properties of weed seeds. Terminal velocities of 20 different weed seeds, which are important for cereals in Europe, were tested.

MATERIALS AND METHODS

The measurements for this study were obtained on an Automatic Test Stand for determining terminal velocity of bulk materials (Fig. 1) at the Institute of Agrotechnology, Hohenheim University.

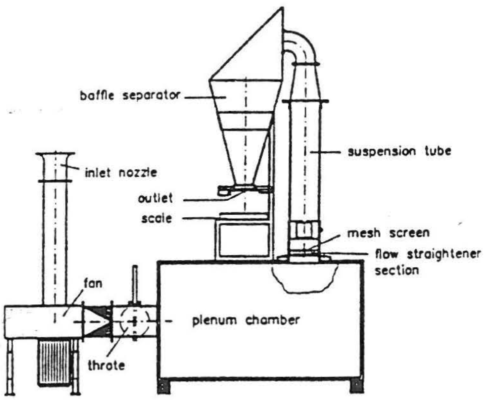

Fig. 1. Automatic Test Stand for determining terminal velocity of bulk material.

In a vertical tube, 1 m long with a diameter of 192 mm, air flows through a mesh sieve on which the sample has been stored before. The air velocity in this tube is controlled by computer as well as the increase of the air velocity, the period of time at a constant air velocity, the outlet of the baffle separator and the scale. All data are collected and reported by the computer. Further details were reported by Barrelmeyer and Beck [1].

For this study different samples of common weed seeds were tested. The seeds were from different sources. *Apera spica-venti,* *Atriplex patulum, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Polygonum convolvulus, Lamium purpureum, Matricaria recutita, Sinapis arvensis, Sonchus asper* and *Stellaria media* were collected from their natural environment. *Avena fatua* and *Galium aparine* were cleaned from seed grain. The rest was grown and harvested on small plots.

Wheat of three different sieve fractions and chaff were tested as well to compare these data.

The weight of each sample was 40 g. Step length of air velocity-increase 0.1 m/s and suspension time at each step 15 s were kept constant for all experiments.

RESULTS

The terminal velocities of 20 different weed seeds and three fractions of wheat are shown in Table 1.

Each sieve fraction of *Triticum aestivum* behaves differently. The fraction of wheat with less than 2 mm in diameter shows the lowest average terminal velocity (Fig. 2a). The fraction <2 mm has an average terminal velocity of 6.4 m/s, the fraction >2.8 mm - 8.8 m/s. Comparing to this Fig. 2b shows characteristic lines of suspension for *Sinapis arvensis, Convolvulus arvensis* and *Galium aparine*. Due to this all three seeds should be found together with grain grown under less intensive conditions. Higher terminal velocites are measured if the moisture content of seeds is high. *Galium aparine* shows a 0.6 m/s higher average terminal velocity at a moisture content of 38.6 % than at a moisture content of 9.3 %, 7.5 m/s instead of 6.9 m/s (Fig. 2c). Chaff shows a curve similar to *Sonchus asper* (Fig. 2c), therefore sorting these two materials by air is impossible.

Table 1. Parameter values for different seeds

Seeds from	Mass (mg)	Req. velocity to separate (m/s)		Terminal velocity (mean) (m/s)	Stand. dev. (m/s)	Coeff. of var.
		1 %	99 %			
Triticum aestivum						
>2.8 mm	51.10	6.1	9.8	8.8	0.79	9.0
2.2-2.5 mm	28.20	5.7	8.7	7.7	0.68	8.9
<2mm	11.60	4.5	7.5	6.4	0.70	11.0
Chaff	-	0.8	2.3	1.6	0.35	22.3
Alopecurus myosursoides	1.82	1.5	4.1	2.9	0.48	16.8
Apera spica-venti	0.11	1.3	2.7	2.0	0.31	15.6
Avena fatua	22.54	3.0	6.2	5.0	0.52	10.5
Matricaria recuita	0.06	1.1	2.0	1.6	0.24	14.4
Sonchus asper	0.25	1.0	2.7	1.8	0.39	20.0
Capsella bursa-pastoris	0.10	1.4	2.8	2.4	0.27	11.4
Myostis arvensis	0.29	1.9	3.8	3.2	0.41	13.1
Cirsium arvense	0.70	1.3	4.7	3.3	0.85	25.9
Lamium purpureum	0.73	2.2	4.3	3.6	0.46	12.7
Stellaria media	0.50	2.4	4.6	3.7	0.52	14.1
Viola arvensis	0.29	2.5	4.6	4.0	0.41	10.2
Thlaspi arvense	1.27	2.7	5.2	4.2	0.48	11.5
Chenopodium album	0.64	2.0	4.8	4.0	0.52	13.1
Atriplex patulum	1.07	2.8	4.8	4.0	0.47	11.8
Rumex crispus	1.35	3.6	4.9	4.4	0.29	6.5
Galeopsis tetrahit	4.57	2.7	5.8	4.9	0.58	11.7
Polygonum convolvulus	4.89	2.5	6.2	4.9	0.75	15.2
Sinapis arvensis	1.90	4.4	6.9	6.0	0.41	6.8
Galium aparine	8.77	5.3	7.7	66.9	0.55	8.1
Convolvulus arvensis	22.36	3.8	9.0	7.8	1.10	13.6

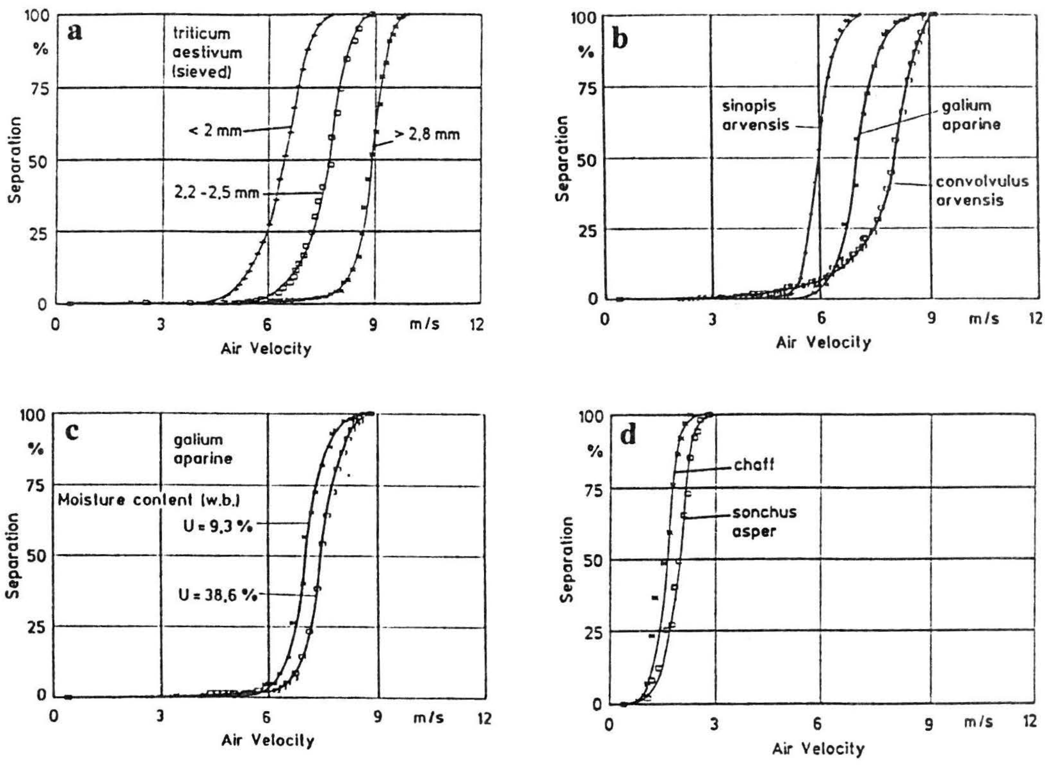

Fig. 2. Characteristic lines of suspension: a - of three different fractions of Triticum aestivum, b - of Sinapis arvensis, Galium aparine and Convolvulus arvensis, c - of Galium aparine at different moisture content (wet basis), d - of chaff and Sonchus asper.

DISCUSSION

Different methods of determining terminal velocity are used. Some scientists test each kernel separately in a special duct. Air velocity is increased until the particle suspends in the air stream [3]. Other authors determine terminal velocity by measuring the falling time of a particle in free-fall [4]. The method used for this study determines terminal velocity of a sample of bulk material in a vertical air-stream. Persson [6] reported of difficulties in connection with this procedure. If samples are large and the period of time at a certain air velocity is long, the curves show lower terminal velocities [7].

Comparing data achieved by using different methods is difficult, but for this study the fraction of wheat 2.2-2.5 mm, kernel weight 28.2 mg, shows about the same average terminal velocity, as Glorial and O'Callaghan [3] found for wheat with a kernel weight of 30.2 mg, 7.7 m/s compared to 7.8 m/s by using a method testing each kernel separatly.

Using terminal velocity as a characteristic, weed seeds can be put into three groups: 1) seeds with similar terminal velocities to *Triticum aestivum*, 2) seeds with characteristic lines of suspension like chaff, and 3) seeds with terminal velocities ranged between groups 1 and 2.

Galium aparine, Sinapis arvensis and *Convolvulus arvensis* represent group 1. Material such as *Apera spica-venti, Matricaria recutita* and *Sonchus asper*, which have terminal velocities similar to chaff are easy to separate from grain and consequently put in group 2. Seeds of this group return together with the MOG on the field again, when grain is harvested with a combine.

CONCLUSIONS

The Automatic Test Stand for determining terminal velocity of bulk material permits determining terminal velocities of different samples with very little effort. Also these data seem to be comparable to data collected with other methods at certain adjustments of the Automatic Test Stand.

Terminal velocities of weed seeds can be grouped into three divisions according to effectiveness of collecting them while harvesting grain with a combine.

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