

FRUITS VARIABILITY OF *ECHINOCHLOA CRUS-GALLI* (L.) P. Beauv. WEED FROM MAIZE CROP

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Abstract

Currently, barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.] is considered a very dangerous weed for agriculture. Its spread is achieved both by adapting to the crop and by the high degree of dissemination. The observations found this weed harms all spring crops, including maize. Controlling them can be relatively easy, including herbicides. In order to promote specific weed management (SWM) have been found useful information on the morphological variability of the species. Panicle characters and kernels showed how plant adaptation held in these conditions. Analysis and measurements showed that the panicle had an average length of 10-14 cm. Panicle formed a number of 16-20 branches with 200-600 spikelets, which weighting 0.4-1.0 g. The mass of a thousand grains was of 1.7-2.0 g. The higher frequency had the spikelets with a length of 2.6-2.8 mm and width of 1.2 -1.4 mm. Regarding the length, the highest frequency was 3.1-3.3 mm. The awn length was between 0.1- 30.0 mm. The correlations obtained between the different characters were positive. Thus, the length of panicle and the spikelets number was close ($r = 0.551^{***}$), as well as of the length to the width spikelet ($r = 0.420^{***}$). Correlation between glume length and awn length was low ($r = 0.132$), and between total spikelets weight with TSW (thousand spikelet weight), rising ($I = 0.503$). The present study demonstrated the wide possibilities of weed adaptation to conditions offered by maize crop.

Key words: E. crus-galli, variability, panicles, spikelets, maize.

1. INTRODUCTION

Being a common species (Maun and Barrett, 1986; Mitich, 1990; Van Acker, 2009; Gressel, 2011), *Echinochloa crus-galli* (L.)P. Beauv. (pro syn *Panicum crus-galli* L., *Pennisetum crus-galli* (L.) Baumg, ECHCG code Bayer, barnyardgrass) is well adapted in maize crop (Bosnic and Swanton, 1997; Clay et al., 2005; Travlos et al., 2011). As an annual plant (Holm et al., 1977; Holm et al., 1991), has a height between of 30 and 200 cm. The stem is glabre with hairs at the nodes. The leaves have 50-65 cm lengths and widths of 5-30 mm, usually hailess. The inflorescence is a panicle

5-25 cm long, provided with hairs, which are sometimes than spikelets. Panicle branches are like spikes, longer at based (1.5-10.0 cm) and short at peak.

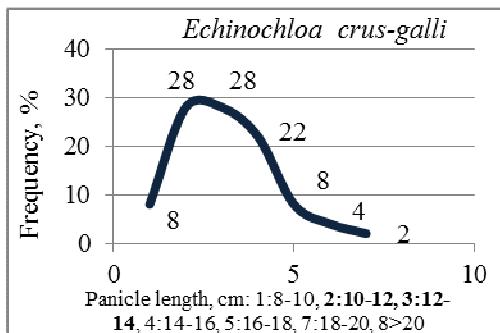
Spikes have many spikelets of 2.5-4.0 mm long, 1.1-2.3 mm wide and are inarticulate at maturity (fall by shaking). Upper glumes are higher as long as spikelets, and lemma can be with awns or not. Awns vary in length among ears and can reach 50 mm (normal 20-50 mm). Down palea is shorter than lemma. Kernels are 1.3-2.2 mm lengths, widths of 1.0-1.8 mm, with ovoid or oblong shape, brown. To these general characteristics (Norris, 1992; Altop and Mennan, 2011), the plant could express some deviations that can be observed by studying their different living conditions. As it is known, a weed that grows in a culture competes with it (Assemat et al., 1981; Ballare et al., 1990; Keeley and Thullen, 1991; Norris, 1992; Perera et al., 1992), and because of this, some changes may result (Gibson et al., 2002; Chauhan and Johnson, 2010). Changes along with the adaptation of weeds (Yamamoto et al., 1999; Xuan et al., 2006) basically can be demonstrated by carrying out study the variability in any growth medium of the weed. Here, research carried out to establish variability (Altop and Mennan, 2011) relate to: the length of panicle, number of branches/ panicle, length of branches, number of spikelets, weight of spikelets, length and width of spikelets, glume length, awn length, and thousand spikelets weight (TSW).

2. MATERIALS AND METHODS

Measurements were made in late August, the last 3 years, on the *E. crus-galli* plant. There were selected several areas under maize in the Southern Highlands. There were chosen randomly among weed-infested areas, with 100 strains *E. crus-galli*. Each of stems with formed panicle were cut, after they were brought to the laboratory. Measurements and determinations of panicles included: absolute length, number of branches/ panicles, spikelets total number, spikelets weight, spikelets length, spikelets width, thousand spikelets weight (TSW), glume length and awn length. Expressions diversity of analyzed characters (Honek and Martinkova, 1996; Gallandt, 2006) was made through a suitable statistical method, by polygon frequency (histogram). Evolution of values from a histogram was established by drawing each character of class intervals. The histogram of specific character revealed the modal value (higher frequency) and variation limits concerned. Further, between the main characters were established some correlations. Such correlations may be obtained by observing important trends in the evolution of these ecotype characters studied. In drawing graphs we used Excel program. Finally, given the multiplicity of measurements and determinations made, proceeded to their statistical processing of namely through variance analysis method. Absolute values were considered as strings-rows processed change. By this method the indices calculated were: media ($\bar{a} = \frac{\sum x}{n}$), variance ($s^2 = \frac{1}{n-1} \left[\sum x^2 - \frac{(\sum x)^2}{n} \right]$), standard error ($s = \sqrt{s^2}$) and variation coefficient ($s \% = \frac{s}{\bar{a}} \cdot 100$).

3. RESULTS AND DISCUSSIONS

Variability of panicles and spikelets characters. The panicle of *E. crus-galli* generally have lengths in the range between 5 (10) and 25 (30) cm. Measurements have shown, however, that the weeds from maize were panicle length between 8 and 20 cm. Their frequency distribution was different length and proved specific (Figure 1). The highest frequency had a panicle of 10-14 cm long (28%), followed by the 14-16 cm (22%), while the short panicle (8-10 cm), and than longer (16-18 cm), were only 8%. The graphs shows a specific variation, precisely because of competition with maize plants.

Figure 1. The frequency of panicle *E. crus-galli* length.Figure 2. *E. crus-galli* weed

Panicle is composed of ear type branches, which may be ascending or adpressed position. Panicle has 2-10 branches, with ears forms, although they may often exceed 10 branches. The number of branches determined was between 6 and 31. The highest frequency had the panicle with 16-20 branches (38%), followed by those of 11-15 (31%) and 21-25 (20%) branches (Figure 3). These branches had the higher lengths from the bottom. The determinations were made only in the middle portion of the panicle. The branches have a length between 1.5 and 4.4 cm. The highest frequency had ones of 2.5-2.9 cm (40%), followed by those of 2.0-2.4 cm (37%). Branches higher between 3.0 and 4.4 cm accounted for 10% of the total (Figure 4).

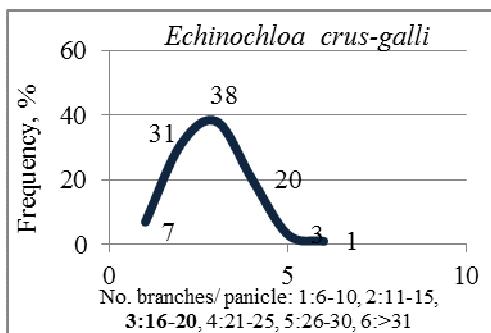


Figure 3 The frequency of branches number/panicle

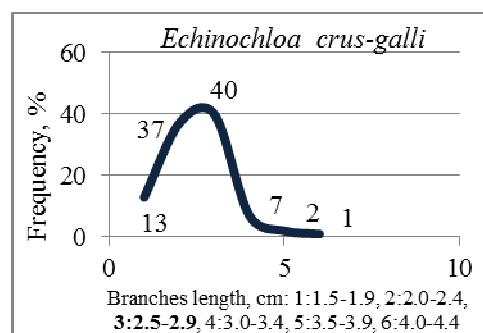


Figure 4. The frequency of branches length

Panicle of *E. crus-galli* form a large number of spikelets with caryopsis. Mature spikelet has green, yellow or brown to purple color. Literature shows that a plant can produce thousands of these fruits (Honek et Martinková, 1966; Maun et Barrett, 1986; Clay et al. 2005). Our data were between 200 and 1200 fruits in a panicle. Highest frequencies of 43% were obtained at 201-400 spikelets and of 42% at 401-600 spikelets. Panicles with over 1000 fruits/panicle were only 4% (Figure 5). These spikelets weight ranged from 0.11 g to 2.50 g. Higher frequency they had class intervals 0.41-0.70 g (35%) and 0.71-1.00 g (36%). 1.31-2.50 g weights accounted for only 5% of the total (Figure 6).

Spikelet is an important component in the composition of *E. crus-galli* panicle. Its dimensions are relatively small, shaped more or less elliptical. The measures have resulted lengths of spikelets between 2.0 mm and 3.7 mm.

Greater frequency had spikelets with 2.6-2.8 mm long (30%). Near them were those with 2.3-2.5 mm (25%) and 2.9-3.1 mm (24%). Smaller lengths and the largest were in total 21% - Figure 7.

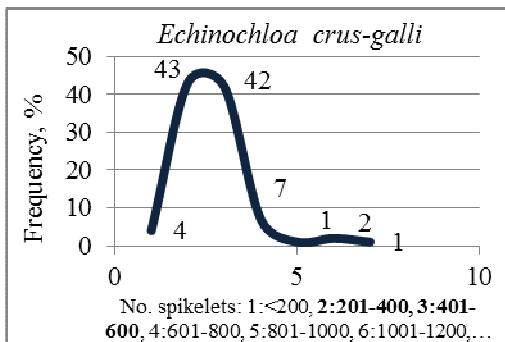


Figure 5 The frequency of spikelets number/ panicle

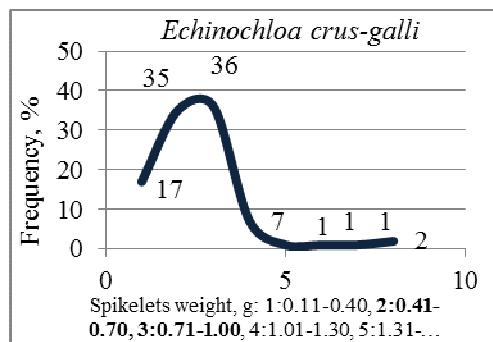


Figure 6. The frequency of spikelet weight/ panicle

Width of spikelets had a different apportionment. Thus, a width of 1.2-1.4 mm of spikelets were dominant (44%). They followed the 1.5-1.7 mm widths (28%) and those with 0.9-1.1 mm (22%). Larger spikelets widths of *E. crus-galli* totaled only 6% (Figure 8).

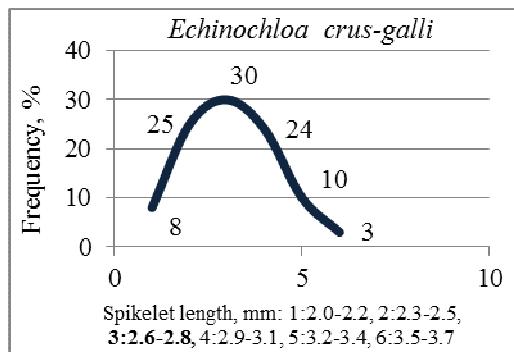


Figure 7 The frequency of spikelet length

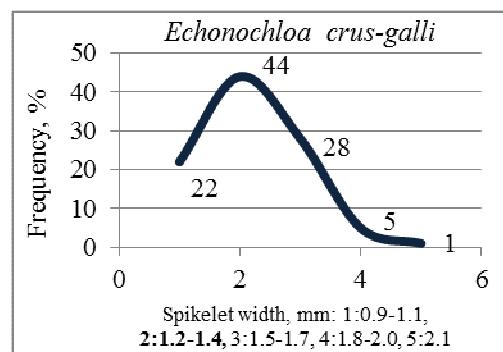


Figure 8. The frequency of spikelet width

E. crus-galli glumes of deltoid shape are short hairy with stiff hairs on the ribs 2-5, that they may have. Length of higher glume is bigger than the spikelet one. The measurements showed that the upper glumes were between 2.6-4.2 mm. The highest frequency was 3.1-3.3 mm (36%), followed by the 2.8-3.0 mm (30%). Glumes of 2.6-2.8 mm were 6%, while those longer than 3.4 mm were in total 28%- Figure 9. Down lemma can have awn or not. The awn can only occur in certain parts of panicle, vary by branch, usually at the top. Measurements were made for the longest awn of the panicle. The values obtained showed that panicle with no awns and awns up to 5 mm were 49%. Panicles with awns of 5-30 mm were 51%. Literature shows that awns of *E. crus-galli* species up to 50 mm. *Echinochloa crus-galli* f. *aristata* (Vasinger) Morariu form with awns over 20-25 mm was prevalent in the populations analyzed by 9% (Figure 10).

Distribution of absolute spikelets weight followed an upward curve from 0.5 to 2.0 g. Further, higher values of 2.0-2.4 fell to 15%. Modal value of TSW was 40% at 1.7-2.0 g weights. They were followed between 1.4-1.7 g values with 27%- Figure 11and Figure 12. Spikelets with 1.1-1.4 g were 11%, those with 0.8-1.1 g represent 4% and the heavier only 0.5-0.8 g.

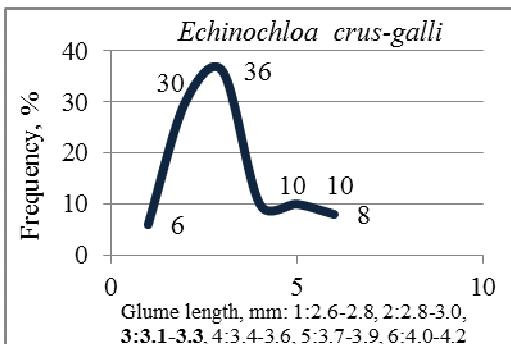


Figure 9. The frequency of glumes length

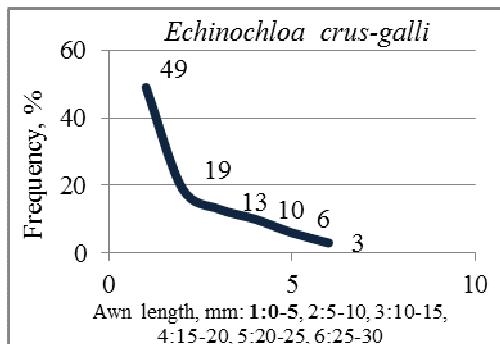


Figure 10. The frequency of awns length

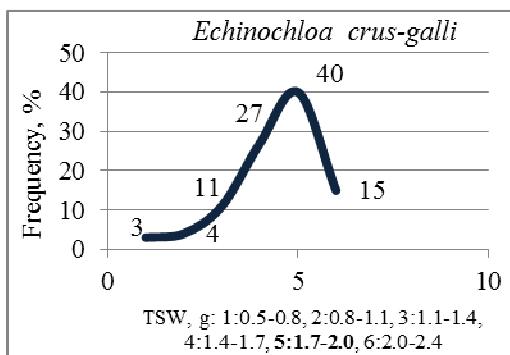
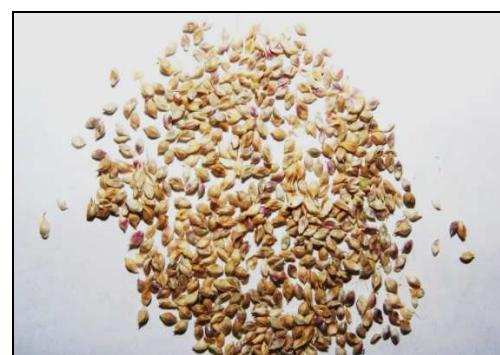


Figure 11. The frequency of TSW

Figure 12. *E. crus-galli* spikelets with caryopsis

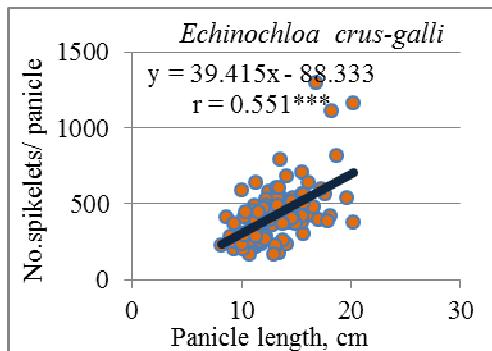
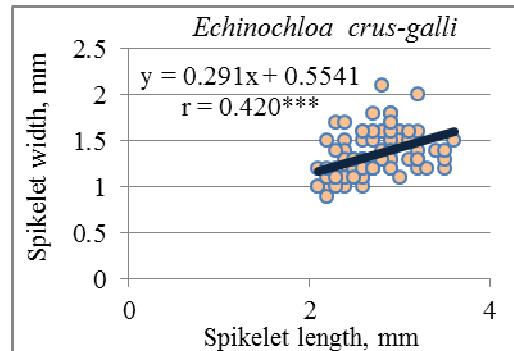
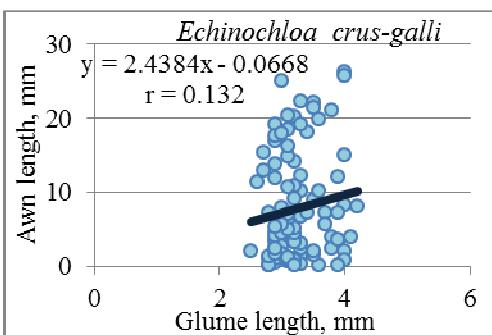
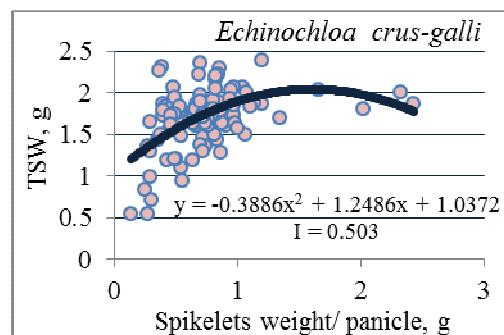
Correlations between different characters. The relationship between the length and the total number of spikelets formed is very strong ($r = 0.551^{***}$), which shows clear dependence between them. The panicle is noted that data had between 8 and 20 cm lengths, and the number of spikelets of them were between 170 and about 1300- Figure 13. Between spikelet dimensions: length and width, it obtained a positive correlation upward ($r = 0.420^{***}$), which highlights here direct dependency between them (Figure 14).

Between glume length and awn length of *E. crus-galli* obtained a positive correlation, but not significant ($r = 0.132$). Cause is a division of awns length range, and made possible by the existence of several forms of plant in the study area [from *f. echinata* (Willd.) Morariu, *f. breviseta* (Döll.) Morariu, *f. submutica* (Neilr.) Morariu, *f. mutica* (Vasinger) Morariu, at *f. aristata* (Vasinger) Morariu]. Absolute values of the length of the glume were scored between 2.4 mm and 4.2 mm, and the length of awn 0 mm (spikelets without awns) and 25 mm (in a panicle) and even 26 mm (we found 2)- Figure 15. Between spikelet weight and TSW achieved a rising correlation ($I = 0.503$)- Figure 16.

Other aspects of variability in *E. crus-galli* fruits. The statistical estimate of the data obtained showed that this species of fruit expression describes the specific way in which weed was adapted in maize crop.

The data refers to the average (\bar{a}), variance (s^2), standard error (s) and the coefficient of variation (%). Values were characteristic oscillations.

Regarding media, it was found that the average length of panicle was 13.25 cm, the average number of branches of a panicle 17, the branches from central portion of panicle measured 2.493 cm, the average number of spikelets of panicle was 434 and their average weight was 0.73 g (Table 1).

**Figure 13.** Correlation between panicle length with number of spikelets/panicle**Figure 14.** Correlation between spikelet length and width**Figure 15.** Correlation between glume length with awn length**Figure 16.** Correlation between spikelets weight/panicle and TSW**Table 1.** Statistic indices of *E. crus-galli* panicles

Indices	Length, cm	Ears no.	Ears length, cm	Spikelets number	Spikelets weight, g
Average, \bar{a}	13.25	17.35	2.493	433.95	0.7338
Variance, s^2	7.136	24.09	0.214	3658	0.1424
Standard error, s	2.671	4.908	0.463	191.27	0.3773
Variation coef., %	20.157	28.288	18.971	44.077	51.417

Tabel 2. Statistic indices of *E. crus-galli* spikelets

Indices	Upper glume length, mm	Spikelet length, mm	Spikelet width, mm	Awn length, mm	TSW, g
Average, \bar{a}	3.243	2.717	1.345	7.841	1.6894
Variance, s^2	0.1491	0.1186	0.0577	51.1991	0.1305
Standard error, s	0.3862	0.3444	0.2401	7.1554	0.3613
Variation coef., %	11.909	12.676	17.851	91.256	21.386

The average length of the spikelet was 2.7 mm and for the glume of spikelet only 3.2 mm. The average width of spikelet was 1.3 mm and average length of awn represents 7.8 mm. The average of TSW was 1.69 g (table 2). The variation of these characters was low at most characters, the spikelets number and spikelets weight were middle and huge variation had awn length.

4. CONCLUSIONS

A common and very damaging species (Lindquist et Kropff, 1996; Krausz et al., 2000) in maize crop is *E. crus-galli*. Its characters, especially the reproductive parts from maize crop are less studied.

Table 3. Structure and analysis values of *E. crus-galli* panicles

Panicle length, cm	Total number of branches	Branch length, cm	Spikelets number	Spikelets weight, g
8-10 8%	6-10 7%	1.5-1.9 13%	<200 4%	0.11-0.40 17%
10-12 28%	11-15 31%	2.0-2.4 37%	201-400 43%	0.41-0.70 35%
12-14 28%	16-20 38%	2.5-2.9 40%	401-600 42%	0.71-1.00 36%
14-16 22%	21-25 20%	3.0-3.4 7%	601-800 7%	1.01-1.30 7%
16-18 8%	26-30 3%	3.5-3.9 2%	801-1000 1%	1.31-1.60 1%
18-20 4%	>31 1%	4.0-4.4 1%	1001-1200 2%	1.61-1.90 1%
>20 2%			>1201 1%	1.91-2.20 1%
				2.21-2.50 2%

For control and stop the infestation can promote morphological variability studies. Between demonstrated variability and complex control measures recently demonstrated the existence of positive trends.

Studies of variation in the species targeted *E. crus-galli* were for panicles and spikelets. The way they expressed variability, revealed features ecotype specific for white luvicsoils (Table 3 and Table 4).

Variability data obtained are considered important both for practitioners to promote specific management (Van Acker, 2009) and for completing the literature data.

Table 4. Structure and analysis values of *E. crus-galli* spikelets

Upper glume length, mm	Spikelet length, mm	Spikelet width, mm	Awn length, mm	TSW, G
2.5-2.7 6%	2.0-2.2 8%	0.9-1.1 22%	0-5 49%	0.5-0.8 3%
2.8-3.0 30%	2.3-2.5 25%	1.2-1.4 44%	5-10 19%	0.8-1.1 4%
3.1-3.3 36%	2.6-2.8 30%	1.5-1.7 28%	10-15 13%	1.1-1.4 11%
3.4-3.6 10%	2.9-3.1 24%	1.8-2.0 5%	15-20 10%	1.4-1.7 27%
3.7-3.9 10%	3.2-3.4 10%	2.1 1%	20-25 6%	1.7-2.0 40%
4.0-4.2 8%	3.5-3.7 3%		25-30 3%	2.0-2.4 15%

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