Original Research Article

Mechanical Damage in the Tillering, Development and Productivity of Wheat

ABSTRACT

Wheat has great economic importance, especially to the Southern states of Brazil, being used as an alternative to the winter period. The aim of this study was to evaluate the effect of mechanical damages in the induction of tillering, development and plants productivity. Treatments were two methods of mechanical damages (kneading and cutting) combined with five induction time of damages (seedling emergence, 7, 14, 21 and 28 days after emergence) and one control (no mechanical damages). Variables evaluated were: tillering, final height of plant, final length of spikes, final number of spikes per m^2, number of spikelets per spike and grain yield. The mechanical damage caused by cutting method did not provide positive effects in the tillering, development and productivity of wheat grain in any induction time of the cutting. The kneading method did not produce any increase of tillers and productivity, but this method also did not decrease the number of tillers and productivity. The results, despite of not conclusive, demonstrate to be promising the utilization of wheat in an integrated crop-livestock system.

Keywords: Triticum aestivum cv. CD 107; winter cultivation; phenological stages; integrate crop-livestock; pasture-management.

1. INTRODUCTION

Wheat has great importance in the Brazilian [1]agricultural scene with planted area about 1,9 million hectares [1]. This crop is one of the most important option of winter cultivation. The states of Paraná and Rio Grande do Sul are responsible for more than 85% of the national production [2].

In the Southern region of Brazil are cultivated spring wheat with the sowing being performed in the autumn. The leaves growth and development occur during the winter, and the flowering and grain filling occur during the spring [3]. Thus, the development cycle of this plant, from the emergence to the physiological maturity, may be divided into two phases: the vegetative and reproductive. When the identification of the phases is based on external morphological indicators of easy identification on field, the vegetative phase may be comprehended from the emergence to the appearance of inflorescence or anthesis, whereas the reproductive phase begins from the end of the vegetative phase to the physiological maturity [4,5].

Knowing the physiological and agronomic characteristics of a crop contributes to the development of production techniques. Thus, one of the characteristics of wheat plant is the tiller, which is a modular unit presents in plants of Poaceae family. The plant tillering is important for production of the species and it is expected that the higher number of tillers result in higher yield [6].

Several studies have been developed aiming to know the influence of tillers in the grains yield. [7] claims that the tillering potential of the species is not expressed in grains yield. However, studies with wheat showed significative gains with evaluation of superior genotypes, in relation to grain yield, spike length, number of grains per spike and weight of one hundred grains in experiments developed under irrigation system [8].

In plant of winter wheat, the American state of Wisconsin recommends an increase of the plants population from 1.300.000 to 1.750.000 plants per acre when the plant is performed later, due to the lower tillering of wheat when low temperatures reach the wheat in previous phases to the beginning of tillering [9]. Thus, a positive effect is observed of the cold on the increase of tillering. This effect is resulted from breaking apical dominance, caused by low temperatures, which consequently stimulates the tillers formation.

The defoliation causes mechanical stress in the plant due to the removal of leaf area, and the defoliation intensity may affect in higher or lower degree the grain and forage yield [10].

The aim of this work was to evaluate the effect of mechanical damages and induction times of damages in the induction of tillering, development, and productivity of wheat plants, replacing the low temperatures which occur in winter wheat plants, since in some years and regions did not occur enough low temperatures for stimulating a higher wheat tillering.

2. MATHERIAL AND METHODS

The experiment was carried out at the Experimental Farm of the Nucleus of Experimental Stations of the State University of Western Paraná (UNIOESTE), Campus Marechal Cândido Rondon, localized at Linha Guará (24°33' of latitude S, 54°04' W of longitude W and altitude of 420 m).
The sowing was performed mechanically in April using a seeder-fertilizer. The chosen area had already been conducted under no-tillage system for four years on the soybean residues. The density used was of 300 seeds per square meter and spacing between lines of 0,17 m. The wheat cultivar used was CD 107, early cycle. According to [11], the soil of the experimental area was classified as Eutroferric Red Latosol with 80% clay. All the treatments culture necessary were made during the performing of the experiment. A topdressing fertilizer was performed at tillering stage, using 40 kg ha^{-1} of N in the form of ammonium sulfate. The plots were constituted by 14 lines with 5 meters long, totaling 11,9 m^2. The useful area of the plot was constituted by six central lines, eliminating 1,5 m of each extremity, totaling 2,04 m^2.
The experiment was conducted in a 2 x 5 + 1 factorial scheme, composed by two methods of mechanical damages (plants kneading and cutting) combined with five induction times of damages (seedling emergence, 7 days after emergence, 14 days after emergence, 21 days after emergence and 28 days after emergence) and one control (no mechanical damages). The experimental design was a randomized block with four replicates.
The kneading and cutting methods were used for artificial induction of mechanical damages. The kneading method consisted to pass a road roller (Fig. 1A) transversely on the plants of each plot in the crop row, compressing the plants at ground level with a compaction of 0,25 kg cm^{-2}. The cutting method consisted to cut the plants at 2,0 cm from the ground (Fig. 1B), using a gardening scissors.

Fig. 1. Mechanical damages in wheat plants: A: Road roller used for plants kneading; B: Appearance of plants with damages caused by cutting.

In the end of the experiment was evaluated: the tillering as a function of the number of tillers per plant; the final height of plants, measuring from the stem to the apex of the spike, disregarding the arista; final length of spikes, measuring from the inferior extremity of the first spikelet, on the spike base, to the superior extremity of the last spikelet, disregarding the arista. Both characteristics were determined at 10 plants randomized in the useful plot. It was also evaluated: the final number of spikes per m^2, counting the spikes from 3 lines of 2 meters long of the useful plot; number of spikelets per spike, counting the number of spikelets formed in each spike; and grain yield (kg ha^{-1}). For this last characteristic evaluated the plots were harvested manually and the results were converted to kg ha^{-1}, corrected at 13% humidity.

The data were submitted to variance analysis and posterior comparison of means by Tukey test [12]. All the analyzes were made using Genes software [13].

3. RESULTS AND DISCUSSION

The variance analysis of the number of tillers per plant in the end of the experiment demonstrated that there was not significant statistics interaction between the method of mechanical damage and induction time. There was only significant statistics difference for the method of mechanical damage, showing a higher number of tillers when the damage was performed by kneading, but it did not differ of the control, no mechanical damages (Fig. 2A). The mean difference between the methods was less than one tiller per plant, what it seems to be a little difference, but it can be expressive if a commercial crop is considered. The final number of tillers per plant was variable among plants, from zero to three, whose coefficient of variation was of 39,12%, considered very high according to [12] and it was also verified by [6] in the wheat tillering of the cultivar IAC370.

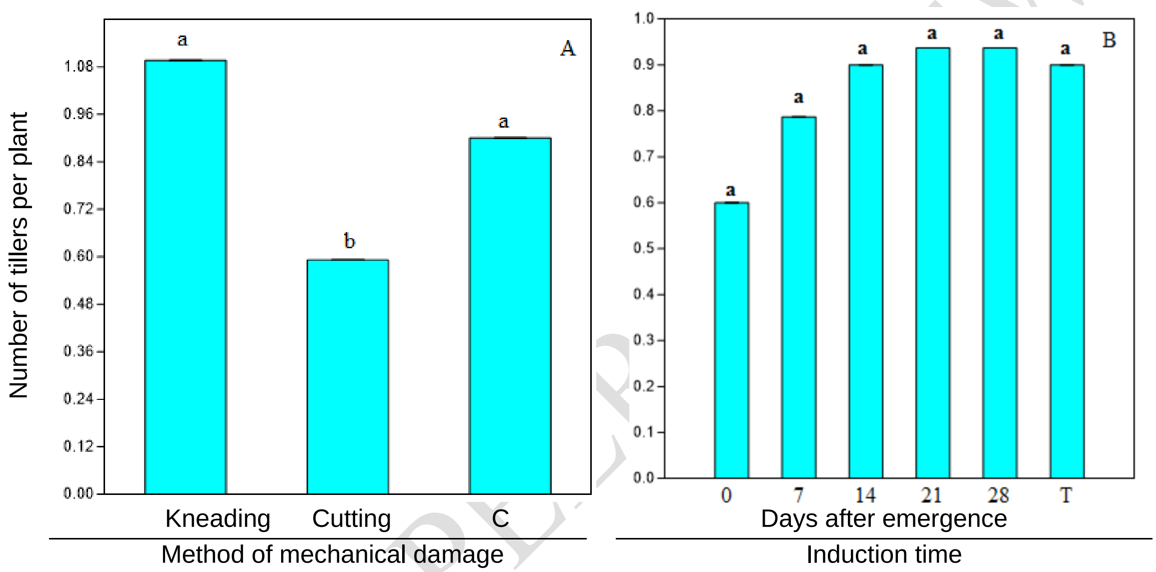

Fig. 2. Final mean number of tillers per wheat plant as a function of methods (A) and induction time (B) of mechanical damages in the wheat cultivar ‘CD 107’.

Means followed by equal letters do not differ from each other by Tukey test at 5% probability, being C the control, and the coefficient of variation of the experiment was of 39,12%.

The interaction between the induction factors and time were significant by F test (P < 0.05) for all other characteristics studied. Therefore, nested means were used to study each factor within each level of another factor (Tables 1 to 5). It is observed that the coefficients of variation were less than 10% for the five characteristics, being considered low according to the classification of [12], demonstrating a good experimental accuracy.

The final height of wheat plants is presented in Table 1. The induction time of the kneading mechanical damage did not affect the plants height. However, the cutting method promoted a significant height reduction when the induction was made from 7 to 28 days. The cutting at the 28 day provided the most drastic production, decreasing the size of the plant by 17.62 cm in comparison to the control. In the comparison of the induction methods, the plants height was inferior by the cutting damage, except when the damage was caused in the emergence. The results show that the cutting does not present itself as a beneficial management for the plant, since the plant height is dependent on the length of the stem that functions as a structure for translocation of assimilates and contributes with grain filling [14].

Table 1. Final height of wheat plants (cm) according to methods and induction time of mechanical damages in cultivar ‘CD 107’

Induction times	Methods	
	Kneading	Cutting

Emergence	89.25 Aa	86.75 Aab
7 DAE	89.87 Aa	82.12 Bbc
14 DAE	89.75 Aa	81.25 Bc
21 DAE	87.50 Aa	81.50 Bc
28 DAE	85.37 Aa	72.25 Bd
Control	89.87 a	89.87 a
$CV_{(\%)}$	2.80	

DAE: Days after emergence.

Means followed by equal letters, upper case in the horizontal and lower case in vertical, do not differ from each other by Tukey test at 5% probability.

The kneading did not influence the spikes final length, except for the damage induction performed at 28 days after emergence that provided a value lower than the control and kneading at 21 days. However, the cutting method provided a shorter spike length, in relation to the control for all cutting times (Table 2). The drasticity of the cutting method influenced negatively the spikes length, due to the depletion of the plants caused by the reduction of biomass during the late stress.

Table 2. Mean values of the final length (cm) of spikes as a function of methods and induction time of mechanical damages in wheat cultivar 'CD 107'

Induction time	Methods	
	Kneading	Cutting
Emergence	6.89 Aab	6.09 Bb
7 DAE	6.88 Aab	6.28 Bb
14 DAE	6.82 Aab	6.07 Bb
21 DAE	6.91 Aa	5.81 Bb
28 DAE	6.40 Ab	5.79 Bb
Control	7.00 a	7.00 a
$CV_{(\%)}$	3.60	

DAE: Days after emergence.

Means followed by equal letters, upper case in the horizontal and lower case in vertical, do not differ from each other by Tukey test at 5% probability.

The final number of spikes per m^2 did not present a statistically significant difference in relation to the control when the kneading method was used. However, for cutting there was a reduction in the number of spikes in relation to the control, in the treatments performed at 14 and 28 days after emergence (Table 3). The time (plant age) which the cutting was made maybe have caused plants to weaken, causing the plants death at 14 days and abortion of tillers at 28 days after emergence. This characteristic becomes important, since the establishment of strategies aimed at increasing productivity must cover the greater use of the agricultural area or the field conditions, increasing the productivity [15,16].

Table 3 – Mean values of the final number of spikes per m^2 as a function of methods and induction time of mechanical damages in wheat cultivar 'CD 107'

Induction times	Methods	
	Kneading	Cutting
Emergence	371.20 Ab	345.32 Aabc
7 DAE	373.55 Ab	344.72 Aabc
14 DAE	424.10 Aab	308.25 Bbc
21 DAE	433.52 Aa	355.90 Bab
28 DAE	415.90 Aab	290.05 Bc
Control	384.12 ab	384.12 a
$CV_{(\%)}$	7.50	

DAE: Days after emergence.

Means followed by equal letters, upper case in the horizontal and lower case in vertical, do not differ from each other by Tukey test at 5% probability.

In the methods comparison, the kneading showed a higher number of spikes per m^2, when the induction was done at 14, 21 and 28 days (Table 3). These results are similar to those reported for four different cultivars, submitted to the cutting or non-cutting management, in which the cutting presented a smaller number of spikes [17]. This is due the stress caused by the cutting method as discussed earlier.
The number of spikelets per spike was similar for all times in the kneading method and had an inferior value only when the damage was done at 28 days using the cutting method. (Table 4).

Table 4. Mean values of spikelets per spike as a function of methods and induction time of mechanical damages in wheat cultivar 'CD 107'

Induction time	Method	
	Kneading	Cutting
Emergence	15.55 Aa	15.92 Aa
7 DAE	16.05 Aa	16.10 Aa
14 DAE	15.95 Aa	15.47 Aa
21 DAE	16.30 Aa	15.10 Ba
28 DAE	14.85 Aa	12.25 Bb
Control	16.02 a	16.02 a
$CV_{(\%)}$	4.58	

DAE: Days after emergence.
Means followed by equal letters, upper case in the horizontal and lower case in vertical, do not differ from each other by Tukey test at 5% probability.

The difference between the methods corroborates the results reported for wheat subjected to mechanical damage by cutting [17] and presumably related to the stress undergone by plants at the time of floral differentiation. Analogous reason is allowed for the smallest number of spikelets obtained when the cutting was performed at 28 days, in this circumstance the plant was close to the stage of floral differentiation and was not able to perfectly recover.
The execution times of the damages did not promote a reduction in grain yield for any of the methods, except for the last time (28 days), when using the cutting method. In the comparison of the induction methods, the cutting was inferior to the kneading method for all periods studied, except in the emergence.

Table 5. Grain yield values (kg ha^{-1}) at 13% moisture as a function of methods and induction time of mechanical damages in wheat cultivar 'CD 107'

Induction times	Method	
	Kneading	Cutting
Emergence	2,385 Aab	2,446 Aa
7 DAE	2,651 Aa	2,130 Ba
14 DAE	2,596 Aa	2,173 Ba
21 DAE	2,665 Aa	2,151 Ba
28 DAE	2,263 Aab	1,587 Bb
Control	2,453 a	2,453 a
$CV_{(\%)}$	6.87	

DAE: Days after emergence.
Means followed by equal letters, upper case in the horizontal and lower case in vertical, do not differ from each other by Tukey test at 5% probability.

The productivity difference between the methods can be related to the greater number of spikes per area, induced by kneading (Table 3), in addition cutting produces greater mutilation of the plant, which can also affect the productivity. In addition to the mutilation promoted by the cutting method, the management itself (cutting) may have been done in a region below the point of growth of the plants, thus promoting abortion of the tines and consequent decrease in productivity [18,19]. The effects of mutilation and elimination of the apical meristem may be more significant in situations of late stress, which would explain the lower productivity when the plants were cut at 28 days.

4. CONCLUSION

The mechanical damages caused by the cutting methods do not promote beneficial effects in tillering, development and productivity of wheat grains in any of execution times.
The kneading method did not produce any tillering increase as well as did not increase the productivity.
The results, although not conclusive, demonstrate that the utilization of wheat in an integrated crop-livestock system is promising.

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