TRITICALE (X *Triticum secale* Wittmack), A NEW CROP IN CUBA. A VARIETAL COLLECTION FROM CIMMYT EVALUATED UNDER THE WESTERN CONDITIONS OF THE COUNTRY

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ABSTRACT. The results from a study conducted on triticale (axenic culture) are presented for the first time in Cuba, after evaluating 49 cultivars from a collection pertaining to the International Center for Maize and Wheat Breeding (CIMMYT). The experiment was carried out at the National Institute of Agricultural Sciences (INCA), where every crop phase length, plant height, yield and its components were evaluated on a multivariate analysis. Results proved that crop phase length differed triticale cultivars within the group, but not its yield nor its components. The most influencing characters on group division were vegetative cycle, anthesis-flowering, arrowing, maturity-harvest and total crop cycle, the latter ones coinciding with the highest contributors on the discriminant analysis for every character analyzed.

Key words: triticosecale, varieties, plant developmental stages, yield components

RESUMEN. Se presentan por primera vez en Cuba los resultados de un trabajo con el triticale (cultivo sintético) mediante la evaluación de 49 cultivares de una colección del Centro Internacional para el Mejoramiento del Maíz y el Trigo (CIMMYT). El experimento se desarrolló en el área experimental del Instituto Nacional de Ciencias Agrícolas (INCA), donde se evaluaron las diferentes fases del cultivo (en tiempo de duración) así como la altura, el rendimiento y sus componentes, en un análisis multivariado. Los resultados mostraron que en los cultivares de triticale evaluados, las fases del cultivo en tiempo de duración fueron las que diferenciaron a los cultivares en el agrupamiento, no así el rendimiento y sus componentes. Los caracteres con mayor influencia en la separación de los grupos fueron el ciclo vegetativo, la antesis-floración, el espigamiento, la maduración-cosecha y el ciclo total del cultivo, coincidiendo estos últimos con los de mayor contribución en el análisis discriminante para todos los caracteres analizados.

Palabras clave: triticosecale, variedades, etapas de desarrollo de la planta, caracteres de rendimiento

INTRODUCTION

Triticale is a new cereal created by the man, which is mainly characterized by its high protein content and agronomic rusticity to grow in marginal areas. It has been expanded throughout the world (1) in about three million hectares (2 924 932 ha), due to its wide adaptability to different soil and climatic conditions. On the other hand, people´s food demands are every time greater in developing countries, as a result of increasing population and decreasing investments for irrigation and other factors; so, the use of marginal areas for cereal production could be the key for the future feeding security, provided that more adaptable crops to these environments are going to be used (2).

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The agronomic characterization and evaluation of different triticale cultivars would be considered a new study under our conditions, since this cereal could be adequately used for animal feeding, which is a problem that is not so far solved in Cuba; in fact, about one million tons of wheat (3) are imported for human and animal consumption, thus, our national needs can not be yet satisfied.

Under the conditions of Cuba, triticale is seeded from October 15 to January 15, but its optimum sowing date is from November 1st through 30. Crop cycle ranges between 95 and 112 days, so it is shorter than in the European growing countries, and its yields are of 2 to 4 $t.ha^{-1}$.

This crop is essentially used for animal feeding (grains and forage) in the world, without excluding highly proteic flour production (14 %) for human consumption (4).

To know how to express its genetic variability in Cuba, more than 49 triticale varieties derived from the International Center for Maize and Wheat Breeding (CIMMYT) were studied under the western conditions of Cuba, based on varietal agronomic behavior, since those cultivars are subjected to environmental variability;

therefore, their characterization, discriminant and cluster analyses were performed with the aim of determining which entries are better adapted to the climate of Cuba.

MATERIALS AND METHODS

Forty nine triticale entries from the International Center for Maize and Wheat Breeding (CIMMYT) were seeded at the National Institute of Agricultural Sciences (INCA), on a compacted Red Ferralitic soil upon deep limestone rock (4), following CIMMYT´s methodology for this crop (5).

Those characters related to its biological cycle were daily evaluated in 20 plants per cultivar since germination, taking into account the scale for small grain developing stages and assigning a specific number to each plant stage, according to Zadok´s decimal code (6):

- Vegetative cycle (TTCIV) in days
- Anthesis-flowering (TTANTFLO) in days
- Arrowing (TTESP) in days
- Maturity-harvesting (TTMADCOS) in days
- Total cycle (TTCICTOTAL) in days.

Also, the following aspects were studied:

- Plant height (m)
- 1000-grain weight (g)
- Crop yield (t.ha^{-1}).

A randomized block design with four replicates was used, making up every replication by 49 plot entries of 3 m long x 2.50 m wide. Data were subjected to a multivariate analysis from SPSS 9.0 statistical package for Windows.

Variables were recodified to keep the same statistical weight, assigning them a minimal value (0) and a top value (1) , as well as proportional scores to intermediate values. As the first step, a k-mean cluster analysis was performed by collecting 49 cases into six to 10 groups, which were subjected to five discriminant analyses. The best group was considered the one whose first discriminant functions could explain the highest variance percentage among groups. The discriminant scores of canonical functions were calculated for group centroids through the discriminant analysis chosen. Such scores served to have a group-linkage dendrogram through a cluster analysis with intergroup links and using the square Euclidian distance, that would enable to know the most important descriptive aspects for group separation.

RESULTS AND DISCUSSION

With regard to the first three canonical functions, the best cultivar grouping was the one having six groups, it explaining 97 % total variance. The highest discriminant character at the first function were the lengths of maturity-harvest, anthesis-flowering, plant cycle and total cycle, the latter in a negative sense, whereas at the second function, the influence of maturity-harvest, arrowing and flowering lengths was predominant and total crop cycle in a negative sense; meanwhile at the third canonical discriminant function, plant cycle, milky grain phase and stuffing time (Table I) were very important. Results showed that different growth and development phenophases predominate when differentiating cultivars gathered in the six groups with a distinct response before the variables studied. In this sense, results were recorded in white lupine, on a main component analysis, in which the variables of yield and its components as well as crop phases were studied, but just explaining the results by 73 % of variance, which also indicates that inflorescence is among the positively influencing characters on yield (7).

Table I. Variance percentages for five canonical discriminant functions and its characters

Function	Selfvalue	Variance (%)	Accumulation (%)	Canonical correlation
1	41.304	51.8	51.8	0.988
2	31.174	39.1	91.0	0.984
3	4.774	6.0	97.0	0.909
4	1.557	2.0	98.9	0.780
5	0.870	1.1	100.0	0.682

What is stated above demonstrates the predominance of different phenophases when differentiating the six groups with distinct responses before the variables studied.

The features of such groups are the following:

Group 1: Made up by nine entries, having a 100 to 103 day-total cycle, a flowering period that ranged between seven and 12 days, as well as by a maturity-harvest cycle, ranging between 26 and 27 days.

Group 2: Made up by 20 entries. This group presented a total cycle that ranged from 99 to 103 days and its flowering period between seven and nine days. On the other hand, its maturity-harvest cycle ranged between 27 and 29 days.

Group 3: Made up by six entries, which are characterized by a total cycle between 100 and 103 days, a flowering period between 12 and 14 days. Its maturity-harvest cycle varied between 24 and 27 days.

Group 4: Made up by two entries, its total cycle varying between 103 and 106 days. As to flowering time, it occurred between nine and ten days, its maturity-harvest cycle ranging between 33 and 37 days.

Group 5: Made up by three entries, which presented a total cycle between 100 and 115 days; its flowering time varied between seven and 11 days. On the other hand, its maturity-harvest cycle ranged from 43 to 46 days.

Group 6: Made up by nine entries. This last group was characterized by a total cycle ranging between 103 and 112 days. Flowering time occurred from nine to 10 days, its maturity-harvest phase varying between 31 and 38 days.

The description of groups made up by 49 entries served to define that, groups 1, 2 and 3 presented a total crop cycle ranging from 99 to 103 days, which is associated to early varieties. Group 4 presented an intermediate total cycle, varying between 103 and 106 days and, finally, groups 5 and 6 represented entries with total crop cycle ranging from 103 to 115 days. Results recorded on the analysis coincided with the different categories, stated in works on springs wheat, for grouping *Triticum* cultivar, according to their cycle length between seeding and harvesting.

Triticale grouping according to its crop cycle length is important for our conditions, since it enables its staggered seeding to be performed according to such variable, which has to be taken into account for this cereal (4, 8). Such issue is of particular importance for the conditions of Cuba, having mind the results of this work.

Figure 1 shows the position of every group, with respect to the first three canonical functions. In relation to the first function, group 4 occupies the highest value since it presented a shorter vegetative cycle phenophase and a longer maturity-harvest period, as well as a phase with the highest number of days for total crop cycle. However, regarding such function, group 3 presented a quite different response, characterized by a shorter maturity-harvest and a longer vegetative cycle. For this function, groups 2 and 5 provided similar values in flowering, maturity-harvest, and total crop cycle phases. On the other hand, groups 1 and 5 were far from the rest concerning function 2. They presented similar phases of flowering, arrowing and total crop cycle, having an opposite direction in relation to groups 2, 3, 4, and 6, which was brought about by flowering and arrowing phases. As to the third function, group 6 occupied a similar position but presented an opposite direction to groups 3 and 4, due to the duration of its anthesis-flowering phenophase. With regard to such phenophase, groups 1, 2 and 5 were placed almost at the same level in both senses, presenting similar features at the same phase.

In this sense, differences could be found among crop phases of diverse cultivars, seeded the same day (9, 10).

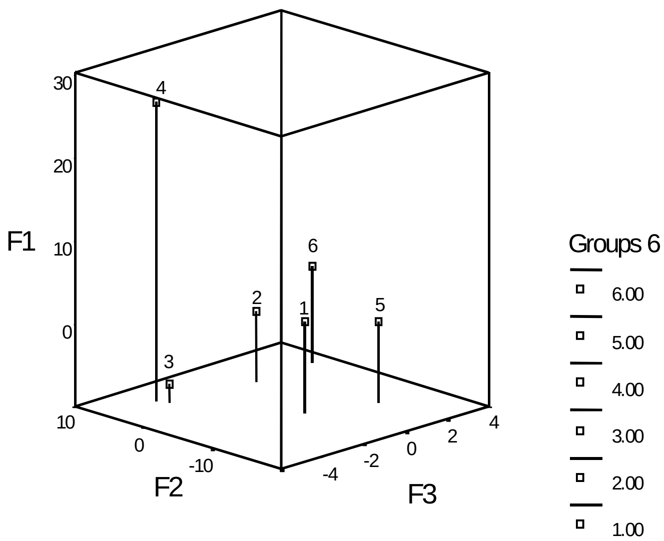

Figure 1. Representation of group centroids according to the first three canonical discriminant functions

Associations among groups can be seen also in the dendrogram (Figure 2). Taking into account values from different characters evaluated for group centroids, made it possible to determine the decisive characters for group division. In this sense, the recorded differences among triticale cultivars were established according to different characters, the several phases of studied genotypes standing out (11, 12).

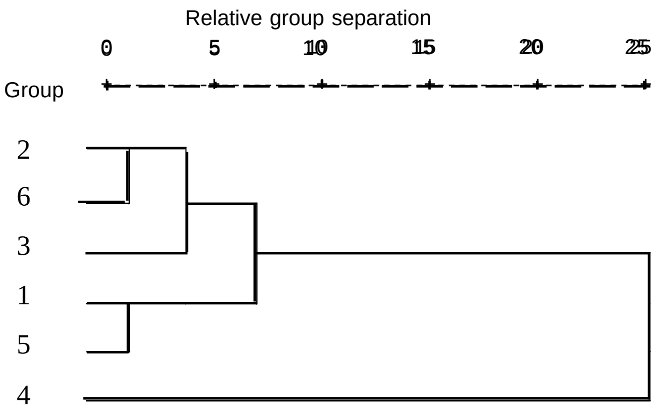

Figure 2. Cluster dendrogram of centroids from six groups of cultivars and main characteristics defining group division

A longer maturity-harvest phase was the first distinguishing character for group 4, presenting a shorter crop cycle for crop 4 than the rest. Anthesis-flowering phase presented a longer crop cycle, which was shorter for the arrowing phase. A division was established between groups 1 and 5, presenting the former features, different from groups 3, 6 and 2, with relatively short flowering and crop cycle phases, in relation to the rest. A third division was established between group 3, with a longer flowering phase and a shorter total crop cycle, and groups 2 and 6, which presented a shorter flowering period and a longer total crop cycle, as well as a shorter anthesis-flowering phase and a longer maturity-harvest period. The fourth division was established from differences between groups 1 and 5, which are mainly given by shorter maturity-harvest and crop total cycle phenophases for group 1, as well as to the opposite behavior presented by the other group, taking into account the same characters.

On the other hand, a fifth and last division between groups 2 and 6 was established, on the vegetative cycle, maturity-harvest and total crop cycle phases, whereas group 2 presented shorter periods for each of these phases.

The most influencing characters on group division were vegetative cycle, anthesis-flowering, arrowing, maturity-harvest, as well as total cycle, the later ones coinciding with those providing the highest contribution on the discriminant analysis, to every character analyzed. In this regard, it was pointed out that morphological and physiological differences among triticale genotypes could affect its growth and development, by joining them into different groups (13, 14).

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