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RESEARCH ARTICLE

BIOMETRY AND GENETIC BREEDING OF DUAL-PURPOSE WHEAT

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ABSTRACT

To obtain genotypes which meet the dual purpose objectives, the breeders are based on the construction of a plant ideo type, showing rapid establishment, tillering potential, high dry matter production per unit area, tolerance to grazing and trample, regrowth capacity, long growing season and short reproductive phase, high quality bromatological forage, and adequate grain yield. The aim of this literature review is to determine the processes and biometric models used to obtainment and selection of dual purposewheat genotypes. The dual-purpose wheat presents as important alternative to the agricultural context, it potentiates energy dynamics in animal nutrition. Thus, the advances in plant genetics and plant breeding as well as in the management of culture to enable the development of genotypes that allow the forage and grain production. This strategy allows the producer to increase the income of rural property, integrate of the crop-livestock activities, reduce the effects of empty feed, maximize the physical space of the property, benefit from the dynamic atmosphere-plant-animal, and economically increase the agricultural activity. The benefits of using genotypes with double purpose are justified through their extensive uses, which replace winter grasses, with higher energy efficiency as forage as grain, this high in starch are for the development of chaffsand feed. Research developed recommended genotypes for wide regions, thus, there are a lack of specific genotypes to micro-regions and different levels of technology management, providing quantitative and qualitative demands of forage and grain, increasing energy supply in farming. Therefore, a genetic breeding program should address effective strategies to identify promising individuals, and enable genetic gains to culture. Today, genetic improvement with emphasis on genotypes for dual purpose does not reveal the necessary importance to the secondary traits, and precarious detailed identification of the interrelationships among feed traits, bromatologic and grain yield. The knowledge of these associations through biometric models, identifying the magnitude and direction of the relationship among traits, makes it possible to guide the selection strategy, and minimize time and financial resources spent.

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INTRODUCTION

The wheat (*Triticum aestivum* L.) is presented as an important cereal in agricultural, social and economic context, and reveals average world production around 650.0000 tons for crop 2012, 2013 and 2014, being behind only corn (USDA, 2015). Countries such as Argentina, Australia, Canada and the United States are the main producers and exporters of wheat. On the other hand, Brazil is evident as the third largest importer this cereal in world. The edaphoclimatic conditions allow the wheat to be grown in various environments and technological levels in this way, the South Region is a leader in production, and the state of Parana is largest Brazilian producer (Conab, 2013). The production chain of this cereal is essential, through the production of grain supplies raw material basis for preparing food products to humans and animals (Mittelmann *et al*., 2000). In animal feed wheat is characterized as a viable alternative to replace the corn, it reveals large availability of raw materials, low cost and high added nutritional value. In this way, it can be directed to prepare rations and sharps for bovine, swine, sheep and poultry (Marques *et al*., 2007). These

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multiple uses are justified through nutritional constitution of its grains, which have 87.77% of dry matter, 54.93% starch, 11.49% crude protein, crude fiber 2.37%, 1.68% of fat, 1.59% of mineral material and 3819 Kcal kg-1 of energy (Rosagno *et al*., 2011). On the other hand, the progress of research in genetic breeding and crop management allowed to obtain dual purpose wheat genotypes, where not only grain production is objectified, but also the ability to provide forage to animals (Bartmeyer *et al*., 2011). By using genotypes with dual purpose, direct and indirect benefits are obtained, such as the diversification of the rural property, better use of space, reduction of periods "feed gap" and food shortages, crop-livestock integration, and rational exploitation of the property (Bortolini *et al*., 2004). To obtain genotypes which meet the dual purpose objectives, the breeders are based on the construction of a plant ideotype, showing rapid establishment, tillering potential, high dry matter production per unit area, tolerance to grazing and trample, regrowth capacity, long growing season and short reproductive phase, high quality bromatological forage, and adequate grain yield (Martin *et al*., 2010; Carvalho *et al*., 2015). Thus, dual-purpose wheat can be used for direct grazing of forage, silage, hay, pre-dried, and the grain for the production of energy to animals, vegetation, and green manure (Fontanelli *et al*., 2009).

Currently in Brazil, the higher use dual-purpose wheat genotypes is concentrated in the South region in contrast, the large cultivated area reveals many producing micro-regions with specific edaphoclimatic characteristics (Fontaneli, 2007). With this, few genotypes are indicated to dual purpose, increasing and the need to meet the needs of producers and the availability of new genotypes. The complexity of the features revealed in a genotype with dual purpose culminates in difficulties to the breeder, where a fraction is attributed to the need of genotype express superiority for morphological traits, bromatologic and components of grain yield, and they will energy supply animals (Martin *et al*., 2013). Today, there are many doubts as to the magnitude and direction of the association among these traits, because the understanding of these interrelations provides guide the appropriate selection strategy. According Coimbra *et al*. (2000), understanding the association among traits is essential to the breeder, because a traitmay be responsible for the expression of another. In contrast, the most successful is given to the breeding program, increasing the chances to gather in a genotype all the desirable characteristics, and that these will serve the needs of producers in various growing conditions. The difficulties faced in selecting superior individuals force the breeder to adopt differentiated and efficient alternatives. According to Carvalho *et al*. (2002) the selection is difficult mainly because the actions resulting from the genotype x environment interaction (G x E), because when the trait of interest is difficult to measure, and it is not feasible to apply the direct selection, determine to which traits are associated will expression of this trait. In this way, is use the indirect selection of secondary traits aiming at genetic gains to the main trait. Studies show that the oscillations genotype response in front to different environments, make indirect selection should be well planned (Cruz and Regazzi, 1997). Indirect selection can be based on a trait easily measurable, high heritability, and is associated with a low heritability trait and highly influenced by the environment (Hartwig *et al*., 2007). To better understand the associations among traits and direct the selection, biometric models can be applied to genetic breeding and result in benefits. Thus, the canonical correlations allows to establish interrelationships among groups of traits involved in the selection (Tavares *et al*., 1999). According to Cruz and Regazzi *et al*. (1997) using this analysis allows the breeder to understand the performance of more than one dependent trait. Studies Coimbra *et al*. (2000) show the great contribution of this method in the selection of superior individuals. In contrast, the path analysis developed by Wright (1921) allows unfolding total correlations in direct and indirect effects, including associations of explanatory traits to the main trait, and enables to reveal the magnitude and direction of associations. Studies Kurek *et al*. (2001) evidence that this tool provides gains in plant breeding, and promising to determine the selection strategy, reduce the time in the selections of genotypes, physical space and financial resources of the breeding program. Thus, the aim of this literature review is to determine the processes and biometric models used to obtainment and selection of dual purpose wheat genotypes.

The origin of culture

Archaeological reports evidence that the first wheat crops date back to 6700 years BC in the Middle East, ancient region of Mesopotamia including the vicinity of the Tigris and Euphrates rivers, today territory of Iraq (Tomasini and Ambrosi, 1998). Wheat is presented as one of the first cultures on the domesticating, was the basis for food from Asian, European and African civilizations, the importance in the food framework provided to this cereal spread over several agricultural areas of the world (Vesohoski *et al*., 2011). The genre *Triticum* presents seven chromosomes in its genome basis, the better known species include wheats diploid, tetraploid and hexaploid, these being *Triticum monococum* L. L. (2n=2x=14), *Triticum turgidum* L. (2n=4x=28), e *Triticum aestivum* L. (2n=6x=42), respectively, (Gill *et al*., 1991). Thus, the common wheat (*Triticum aestivum* L.) is evident as a set of three complete diploid genomes, featuring a allopolyploid (AABBDD), where each genome is derived from a species being *Triticumurartu* (AA), *Aegilopsspeltoides* (BB), e *Aegilopstauschii* (DD) (Brenchley *et al*., 2012). Because it is allopolyploid, wheat reveals polissomic heritage to its characteristics, this way, one gene in one of the genomes, may be contained in the other (MoraesFernandes, 1982). Studies show that the wheat adaptability to different environmental conditions, is justified by the complexity of its genome (Walter *et al*., 2009). This fact leads to peculiarities regarding the pattern of segregation and the incorporation of genes, and genetic breeding aims to obtain appropriate genotypes agronomically and that may enhance traits beneficial to conditions of biotic and abiotic stresses,better response to interaction genotype x environment, and provide increased crop yield (Federizzi *et al*., 1999).

Botanical description

The common wheat is characterized as a grass belonging to the kingdom Plantae, division Magnoliophyta, Liliopsida class, order Poales, Poaceae family, genre *Triticum* L. and species

Triticum aestivum L. (Dedecca e Purchio, 1952). The study Slageren (1994) classify six species *Triticum* genre, being *Triticum urartu*, *Triticum monococcum*, *Triticum turgidum*, *Triticum timopheevii*, *Triticum zhukovskyi* and *Triticum aestivum*. Regarding the species *Triticum aestivum* subdivisions exist, these being, *Triticum aestivum* subsp. *aestivum*, *Triticum aestivum* subsp. *compactum*, *Triticum aestivum* subsp. *mancha*, *Triticumaestivum*subsp. *spelta* e *Triticum aestivum* subsp. *sphaerococcum*.

Morphological and physiological characteristics of wheat

The wheat crop has an annual cycle, and plants with cespitose growth habit, including genotypes with heights from 0.30 to 1.50 meters. The root system is characterized as fasciculated dimensions and can reach 0.30 to 0.40 meters. The stem is classified as stem is composed of nodes and internodes, responsible for the insertion of the leaves and stem elongation, respectively. The leaf is composed of the sheath, which is characterized as an elongated structure and attached to the stem, the ligule is membranous and whitish and the leaf lamina presents a linear with paralelinérveasribbing. The auricle reveals small to medium in size and can express hairiness (FontanelI *et al*., 2012). Among the wheat characteristics, thetillering shows is extremely important to the productive part of the genotypes for providing compensatory effects by issuing tillers photosynthetically active, contributing assimilated into the main stem and form reproductive structures. According to Valério *et al*. (2009) the magnitude of tillers per plant, reflects the number of ears per unit area, number and mass of grains per plant and therefore grain yield genotype, provided that they are self-sufficient and not offered as a drain assimilated to the plant. Wheat tillering can be controlled by genetic effects, hormone through the auxin and cytokinin, characteristic cultivation environment, water and nutrient demand, and the arrangement of plants in the canopy (Valerio *et al*., 2009). The tillering for the dual-purpose wheat presents essential because increases the number of leaves, leaf area and forage production (Martin *et al*., 2010). According Bortolini *et al*. (2004) indirectly reduces establishment of plants, apical dominance and plant height. Studies Santos *et al*. (2011) show that the management cuts in dual purpose genotypesresults in stimulating the emission of tillers, leaf area increment, interception and utilization of photosynthetically active radiation.

Wheat development periods are divided into vegetative and reproductive comprising seedling emergence to the appearance of the inflorescence and later to physiological maturity, respectively (Streck *et al*., 2003). The inflorescences are called ears, being formed by a number of spikelets adhered individually to the rachis node. Studies have shown the great wheat's ability to modify the magnitude of spikelets per ear, through population management, nutrition, and genetic characteristics of the cultivar (Teixeira Filho *et al*., 2008). In spikelets are present three hermaphrodite flowers, with two viable and central to certain degree of sterility. The flower shows in the male carpel three anthers, and the female apparatus reveal are two stigmas and an ovary. Reproductive carpels are surrounded by anthecium, which is formed by the palea and lemma, after autofertilization, pollen grain germination, issue of the pollen tube and ovarian development, formed the fruit called a cariopse, responsible for generating new individuals and propagate the species. Studies show that pollen viability and fertilization of flowers, are closely related to the cultivation environment, directly influencing productivity and seed quality (Ribeiro *et al*., 2012).

The dual purpose wheat

The dual-purpose wheat is characterized as dual purpose of cereal for providing forage in the growing season, and then provide the grain harvest (Martin *et al*., 2010). According Hastenpflug (2009), the grains produced are for the production of meal and feed, in contrast. Studies by Ribeiro *et al*. (2010) show that the dual-purpose wheat can reduce the needs of raw materials in the preparation of rations and efficiently replace corn, and wheat showed lower aggregate price, high nutritional value and availability of grain in between harvest corn. The dual purpose is evident as widely energy alternative to the agricultural context, as energy source for animals both in vegetative as reproductive period. Forage presents 23.00% crude protein, 53.00% of neutral detergent fiber and 26.80% acid detergent fiber (Fontanelli *et al*., 2009). On the other hand, the grains provide 87.77% dry matter, 54.93% starch, 11.49% crude protein, crude fiber 2.37%, 1.68% fat, 1.59% material mineral and 3,819 Kcal kg^{-1} of energy (Rosagno *et al*., 2011). This strategy allows to gather successfully activities related to different areas of agribusiness, thus, the crop-livestock integration enables economically improve the rural property. Studies Del Duca *et al*. (2000) show mutual benefits of crop-livestock integration to the soil, plants and animals, as well as increase the economic producer gain in the same physical space. The dual purpose allows you to provide forage to animals directly, or mechanically elaborate pre-dried, hay and silage, on the other hand, the grains produced can be used as an energy source in animal feed (Fontaneli *et al*., 2009). The Southern Region of Brazil shows some peculiarities as for fodder production. Many of the species used have fixed production period, it directly influences the scarcity of feed. Studies reveal that the feed gapoccurs in the fall and early winter (Meinerz*et al*., 2011). Thus, dual purpose wheat genotypes minimize the adverse effects of lack of food, because it allows early seeding have rapid establishment, tolerance to trampling, high-yield forage and chemical quality of the material produced (Fontaneli *et al*., 2009). Studies Wendt *et al*. (2006) showed that the genotypes should have long vegetative period and enable more cuts, in contrast, short reproductive period.

The dual-purpose wheat reveals some care for the management of the plants when they are rationally followed the activity results in successes in the productive and economic context. The well-used management techniques provide increasing the number of cuts, increased forage harvesting and regrowth capacity, studies show that the intensity of the stress caused to plants by the loss of leaf area, can affect as the forage as grain yield (Bortolini *et al* ., 2004). Thus, some criteria should be considered, such as fertilization balanced in the period of seeding and coverage after each cut, among the crop needs emphasizes the addition of nitrogen, in order to enhance the regrowth and recovery from plants of the stress defoliation.

Studies Sangoi *et al*. (2007) show that the application of nitrogen in wheat, promotes increased magnitude of fertile tillers and grain yield. In cereals for the dual purpose, nitrogen assists in the establishment of leaf area and forage crude protein content (DelDuca *et al*., 1999). Another important aspect is the input period and exit of the animals to the grazing, and the cutting height in a mechanized management, the absence of this care can result in damage to the apical plant meristem, impairing elongation and grain yield (Martin *et al*., 2010).

Therefore, for high forage production genotypes dual purpose minimizing the effects of feed gap, one must anticipate the seeding 20 to 30 days, and the density can be increased compared to traditional wheat (Wendt *et al*., 2006). The applicability of these management techniques is dependent on the cultivation environment, temperature, photoperiod, water supply, soil and production cost (Martin *et al*., 2010). Recommended dual-purpose wheat genotypes were developed from 2002 through research at Embrapa Temperate Climate and Embrapa Wheat (Wendt *et al*., 2006). The main genotypes are BRS Figueira launched in 2002, coming from the crossing Coker 762*2/Cnt8, BRS Umbu released in 2003 by the parents Century/BR 35 in 2004 were released BRS Guatambu and BRS Tarumã by outcrossing Friend/2*BR23 and Century/ BR35 respectively, and BRS 277 released in 2008 by the parents OR/Coker 93.33 (Cairão *et al*., 2014).

The genetic breeding and obtaining genotypes

A breeding program of wheat that aims to get new genotypes must have an organized systematic and follow steps as defining the objectives, choice of progenitors, hybridizations, formation of segregating populations, choice of training method and selection, preparation of competitive assays, registration and protection of genotype, multiplication and distribution of seeds. Obtaining a genotype for the dual purpose it can be considered as primary objective of the breeder. In this way, we seek to build a plant ideo type bringing together high-yield forage and bromatologic quality, great tillering potential, tolerance to defoliation and trampling, and adequate grain yield, increasing the energy supply to the animals (Wendt *et al*., 2006). The selection of progenitor is important to obtain new genotypes, because it seeks to gene complementarity between progenitors in order to increase the expression of agronomic traits of interest (Pimentel *et al*., 2013). Wheat studies reveal that the breeder can increase genetic variability by the use of cultivars in use, elite cultivars, landraces and breeding lines (Skovmand *et al*., 2006). After the selection of genotypes with characteristics of interest that meet the proposed objectives, are organized intersections blocks, directing the crossings to provide segregating populations with high expression of objectified traits (Schmidt *et al*., 2009). The wheat has hermaphrodite flowers, where cleistogamia provides autofertilization through the flower capacity should fertilize before the opening of the petals. Under these conditions the breeder promotes the emasculation of flower and remove the three anthers, after is carried out the inflorescence protection. Later direct to the anthers with viable pollen male parental genitor with deposition on the stigma of the emasculated flower, identifying the intersection with the necessary appropriate information (Allard, 1971).

Viable crossings generate completely heterozygous individuals, resulting in the formation of segregating populations. Studies show that the success of a genetic breeding program of wheat is closely related to the breeder's ability to increase genetic variability in segregating populations derived from crosses (Pimentel *et al*., 2013). According Ramalho *et al*. (2012) the breeder's actions should be informed in populations with high average of traits of interest, and show high genetic variability. Among the methods of selection and conduct of plants in genetic breeding wheat with hybridization, we highlight the use of mass selection, population method, genealogical method and descended from just a seed "Single Seed Descent" (SSD). All methods are performed from the second generation descendants of "F2" (Borém and Miranda, 2013). The mass selection has lower cost and need for hand labor, reveals great contribution of natural selection through the conditions of cultivation environment. Populations seeded in commercial density of F2 to F4, the best plants are harvested and mixed in F5 generation seeding will be spaced. The grounded selection in the phenotype will result in the generation F6, F7 make up the competition tests (Scheeren *et al*., 2011). The genealogical method or pedigree is grounded directly in the evaluation of the progenies, where the generated population is seeded to form spaced and individually evaluated in F2 where superior individuals are selected and harvested separately. Each plant will form a thread F3, in F4 the selection is grounded not only in morphological traits but in traits generated of the progeny, the selection of the best lines is repeated until homozygous be achieved. After it is realized the cultivation value of cultivation and use (VCU) with commercial witnesses, but selected plants should be planted at the time and place where the future will be used genotype (Borém and Miranda, 2013). According Allard (1971), this method is suitable for qualitative characteristics determined by the trait of great effects genes.

The population method is based on the conduct of F2 populations under the same conditions of the future genotype, they should be collected in bulk. A sample of the previous generation is seeded to form the next generation of F3 to F5. F6 plants with promising phenotypes seeded in line, and then the best lines are harvested in bulk and submitted to the cultivation value of cultivation and use (VCU) with commercial checks (Borém and Miranda, 2013). The method Single Seed Descent (SSD) is performed through the collection of only a seed of each F2 individual. This seed will generate the individual of the next generation F3 to F5, being cultivated in spaced form. The best lines are selected in F6 and subjected to performance tests with other witnesses, this method provides the generation of advancement in the same year in the greenhouse, maintaining the variability of the original population, and in each generationhomozygosity is increased (Borém and Miranda, 2013).

Biometric models to identify traits of interest in the selection

The canonical correlations have function to estimate the maximum correlation among the groups of traits, and these traits tend to respond linearly (Cruz*et al*., 2012). This analysis minimizes the problems related to the presence of only a dependent trait, because do not distinguish which traits are dependent or independent, and provides revealing the maximum correlation among the groups (Morrison, 1978). Cruz *et al*. (2012) shows that this method allows to analyze the interrelationships of groups with varying number of traits, and associations are explained simple way through a few correlations (Cruz and Regazzi, 2004). The determination of associations among groups is possible by the presence of at least two traits of importance (Cruz *et al*., 2012). Where the number of canonical correlation is equal to the number of traits that make up the smallest group, and the magnitude of these correlations is inversely proportional to the order that were estimated (Cruz and Regazzi, 2006). Studies by Cruz *et al*. (2012) show that the statistical problem is linked to the estimated maximum linear correlation among groups, which promotes determining a weighting coefficient each linear correlation of traits. The estimation of these coefficients for traits of interest to genetic breeding facilitates the identification of promising individuals through indirect selection of easily measured traits. According to Carvalho *et al*. (2004) understanding of the relationship among traits allows to increase the efficiency of the selection, and reflects the success of the breeding program. Studies Santos and Vencovsky (1986) show that the correlation possible to identify associations among traits and reveal the grounded selection on a particular trait may cause effects to the other traits. The canonical correlation shows to be beneficial to genetic breeding, and provides an understanding of the associations among groups of agronomically important traits (Coimbra *et al*., 2000). The path analysis was described by Wright (1921) and used in (1923) which provides a better understanding of the associations among traits, through the unfolding of simple correlations, further detailed studies were conducted by Li (1975). This methodology quantifies the magnitude and direction of associations among complex traits, revealing the importance of direct and indirect effects on the dependent trait (Cruz *et al*., 2012). These effects are obtained by regression equations in standard traits (Cruz *et al*., 2006). This analysis is characterized by giving associations allow to determine the interrelationships of cause and effect in the studied traits in breeding is commonly used to determine the importance of primary and secondary traits of culture, and guide the indirect selection of promising genotypes through traits of interest (Cruz *et al*., 2012). According to Nogueira *et al*. (2012) understanding of the associations among traits is vital to genetic breeding, for assisting in directing the selection process.

The path analysis shows characteristics for being a regression coefficient, and reveal positive or negative direction. It is characterized with a standardized coefficient which allows traits to relate measured in different physical units not expressing notations in their results (Cruz *et al*., 2012). In genetic breeding it is necessary to identify which traits showed high correlation with the main trait, where the direct effect must have favorable sense to selection, in contrast, opposite directions between total correlation and the direct effects indicate no association of cause and effect (Cross *et al*., 2006). Studies Cruz *et al*. (2004) show that indirect selection shows to be viable, and can be practiced for traits difficult to measure low heritability and highly influenced by the environment. The definitions of the associations allow the breeder to understand the importance of each trait in the expression of others. Thus, the path analysis seeks to elucidate the relationships among traits, for indirect selection when not based on the effects of other traits may reveal changes in non-desirable characteristics (Santos *et al*., 2000). Studies Ramalho *et al*. (1993) show that the correlation and associations amongtraits are important to plant breeding, to determine the effect of selection proceeded in a certain trait, that will influence the other traits culture.

Final Considerations

The dual-purpose wheat presents as important alternative to the agricultural context, it potentiates energy dynamics in animal nutrition. Thus, the advances in plant genetics and plant breeding as well as in the management of culture to enable the development of genotypes that allow the forage and grain production. This strategy allows the producer to increase the income of rural property, integrate of the crop-livestock activities, reduce the effects of empty feed, maximize the physical space of the property, benefit from the dynamic atmosphere-plant-animal, and economically increase the agricultural activity. The benefits of using genotypes with double purpose are justified through their extensive uses, which replace winter grasses, with higher energy efficiency as forage as grain, this high in starch are for the development of chaffs and feed. Research developed recommended genotypes for wide regions, thus, there are a lack of specific genotypes to micro-regions and different levels of technology management, providing quantitative and qualitative demands of forage and grain, increasing energy supply in farming. Therefore, a genetic breeding program should address effective strategies to identify promising individuals, and enable genetic gains to culture. Today, genetic improvement with emphasis on genotypes for dual purpose does not reveal the necessary importance to the secondary traits, and precarious detailed identification of the interrelationships among feed traits, bromatologic and grain yield. The knowledge of these associations through biometric models, identifying the magnitude and direction of the relationship among traits, makes it possible to guide the selection strategy, and minimize time and financial resources spent.

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