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Phenotypic associations for forage and bromatologic traits in dual-purpose wheat

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ABSTRACT

Background: The wheat (*Triticum aestivum* L.) for the dual purpose brings together features such as supply of carbohydrates, proteins, lipids, minerals, fiber and vitamins as far to humans through the grain, as for the animals through forage production. Thus, the aim of this study was to determine the phenotypic relationships of cause and effect between foragers and bromatológicos traits of dual-purpose wheat under different cutting managements. **Methods**: The experiments were conducted in the crop year of 2013 and 2014 in Frederico Westphalen – RS. The experimental design was randomized blocks arranged in a factorial design, genotype x cutting managements, where the crop year were not considered for the breakup of its effects being used to best represent the response of traits. In this way was used: five genotypes and three cutting managements, the treatments were arranged in three replications. The genotypes dual-purpose wheat were: BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu and BRS 277. The cutting managements employees were first cut, second cut and third cut. The data were submitted to analysis of variance in order to verify their homogeneity through the Bartlett test. After held jointly consider all cutting managements through *Pearson* correlation coefficients, aiming to demonstrate the existence of trends between traits. Afterwards was carried out the diagnosis of multicollinearity to check the number of conditions between the characters for each cutting management, and proceeded to phenotypic path analysis, making the decomposition of the correlation between the dependent variable (percentage of crude protein) and the explanatory variables. **Result:** The analysis of variance for the *Pearson* linear correlation and the analysis of individual variances for the first cut, second cut and third cut revealed that all of the characters differ significant a p> 0.05 error probability. **Conclusion:** The indirect selection increase the percentage of crude protein in the first cut may be based on percentage of total carbohydrates, non-fibrous and green mass yield per hectare. The second cut provides indirect selection with a percentage of non-fibrous carbohydrates, green mass yield and drought per hectare. The increase of crude protein in the third cut may be obtain through indirect selection to the percentage of cellulose, mineral material, green mass yield and dry per hectare. Indirect selection through forage and bromatologic character can be successful, since it considers the effect assigned to each cutting management.

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INTRODUCTION

The wheat (*Triticum aestivum* L.) for the dual purpose brings together features such as supply of carbohydrates, proteins, lipids, minerals, fiber and vitamins as far to humans through the grain, as for the animals through forage production (Hidalgo *et al*., 2016). The double-purpose cultivation allows circumvent the intrinsic adversity to the productive system, for has fast development, high production forage and chemical quality in this way, the effects of empty forage may be minimized through highly productive genotypes reconciled to crop integration strategies, perfecting rural property (Martin *et al*., 2013; Carvalho *et al*., 2015; Wang *et al*., 2015).

Faced with the need to provide genotypes that meet higher forage yield and high proportions of crude protein, it is essential to understand the interrelationships between characters linked to forage scope and bromatological value. Thus, to elucidate the actions of cause and effect of the correlation coefficients in the traits involved, it takes place the partition in direct and indirect effects through path analysis (Wright, 1921).

The unfolding of associations between traits to quantify the contribution of each trait to the percentage of crude protein, and highlight the phenotypic effects assigned to each cutting management. Thus, one can infer viable strategies of indirect selection aiming genotypes that meet the foragers and bromatological needs. Thus, the objective of this study was to determine the phenotypic relationships of cause and effect between foragers and bromatológicos traits of dual-purpose wheat under different cutting managements.

MATERIAL AND METHODS

The experiments were conducted in the crop year of 2013 and 2014 in Frederico Westphalen - RS. The coordinates correspond to latitude 27 39 '56 "S and longitude 53o 42' 94" O, with an altitude of 490 meters. The soil is classified as Oxisol Alumino, and the climate is characterized by Köppen as CFA and subtropical. The experimental design was randomized blocks arranged in a factorial design, genotype-cutting managements, where the crop year were not considered for the breakup of its effects being used to best represent the response of traits. In this way was used: five genotypes and three cutting managements, the treatments were arranged in three replications. The genotypes dual-purpose wheat were: BRS Tarumã, BRS Umbu, BRS Figueira, BRS Guatambu and BRS 277. The cutting management's employees were first cut, second cut and third cut. The criteria used to carry out the cuts was based, when the plants reached an average height of 0.3 meters from the ground level to the last fully expanded leaf in this way, we proceeded to the manual cutting of all experimental unit at the time 0.1 meters from the ground level (Martin *et al*., 2013).

Each experimental unit consisted of 12 lines spaced 0.17 meters and 2.0 meters long. The employed population density for all genotypes dual-purpose wheat was 3,000,000 ha^{-1} plant. In both crop years was the direct seeding of the treatments carried out based fertilization of 250 kg ha^{-1} NPK formulation (10-20-20), coverage was applied to a total of 90 kg ha^{-1} of nitrogen in the form of urea, parceled out in full tillering and after each cut. The control of insect pests and diseases was done preventively. Reviews and samplings were made in the central lines of each experimental unit, despising 0.5 meters at the ends, in order to reduce the effects of surround.

The evaluated traits were: green mass per hectare (GM) kg ha^{-1}, dry mass per hectare (DM) kg ha-^{1}, percentage of hemicellulose (HEM), cellulose (CEL) and mineral material (MM) obtained by Silva and Queiroz (2006), fiber percentage of neutral detergent fiber (NDF) and acid detergent fiber (ADF) obtained by Senger *et al*. (2008), lignin percentage (LIG) obtained by Robertson and Van Soest (1981), percentage of total carbohydrates (TC) and non-fiber carbohydrates (NFC) obtained by Sniffen *et al* (1992), crude protein percentage (CP) obtained by Nogueira and Souza (2005), percentage of lipids (LIP) obtained by Bling and Dyer (1959).

The data were submitted to analysis of variance in order to verify their homogeneity through the Bartlett test (Steel *et al*., 1997). After held jointly consider all cutting managements through Pearson correlation coefficients (Steel *et al*., 1997), aiming to demonstrate the existence of trends between traits. Afterwards was carried out the diagnosis of multicollinearity to check the number of conditions between the characters for each cutting management (Cruz and Regazzi, 1997), and proceeded to phenotypic path analysis, making the decomposition of the correlation between the dependent variable (percentage of crude protein) and the explanatory variables, following the methodology of Cruz *et al*. (2004). For making, the analysis used the statistical software Genes (Cruz, 2013).

RESULTS AND DISCUSSION

The analysis of variance for the Pearson linear correlation (Table 1) and the analysis of individual variances for the first cut (Table 2), second cut (Table 3) and third cut (Table 4) revealed that all of the characters differ significant a $p> 0.05$ error probability. The estimate of Pearson linear correlation (Table 1) consists of all cutting managements aimed to reveal the trend of the magnitude and direction of associations between forage and bromatologic traits in wheat genotypes with double-purpose.

Table 1: Estimates of the Pearson linear correlation for forage and bromatologic traits in five genotypes double-purpose wheat for all cutting managements, Frederico Westphalen - RS, 2015.

Traits	LIP	NDF	ADF	LIG	HEM	CEL	MM	CP	TC	NFC	GM	DM
LIP (1)	-	-0.63*	-0.65*	-0.23	-0.55*	-0.71*	0.18	-0.10	-0.42*	0.53*	-0.04	-0.62*
NDF		-	0.92*	0.46*	0.97*	0.90*	-0.23	-0.10	0.42*	-0.94*	-0.16	0.75*
ADF			-	0.54*	0.82*	0.95*	-0.20	-0.03	0.38*	-0.87*	-0.03	0.81*
LIG				-	0.36*	0.34*	-0.23	0.04	0.23	-0.42*	-0.06	0.40*
HEM					-	0.81*	-0.26	-0.12	0.42*	-0.90*	-0.24	0.66*
CEL						-	-0.2	-0.05	0.42*	-0.83*	0.00	0.83*
MM							-	0.15	-0.87*	-0.06	0.24	-0.15
CP								-	-0.48*	-0.06	0.09	0.06
TC									-	-0.09	-0.21	0.29*
NFC										-	0.09	-0.71*
GM											-	0.20
DM												-

* Linear correlation coefficients of Pearson (n = 90) significant at 5% error probability (1).LIP: lipids percentage; NDF: fiber percentage of neutral detergent fiber; ADF: fiber percentage in acid detergent fiber; LIG: lignin percentage; HEM: percentage of hemicellulose; CEL: cellulose percentage; MM: mineral material percentage; CP: crude protein percentage; TC: total carbohydrate percentage; NFC: percentage of non fibrous carbohydrates; GM: green mass yield per hectare; DM: dry matter yield per hectare.

The Pearson linear correlation held to 12 traits (Table 1) showed 66 associations, where 35 are significant. Regarding the percentage of character lipids (LIP) positive correlation is revealed with NFC (r = 0.53), and negative with NDF (r = -0.63), ADF (r = -0.65), LIG (r = -0.23), HEM (r = -0.55), CEL (r = -0.71), PC (r = -0.42) and DM (r = -0.62). Studies Oliveira *et al*. (2007) shows that lipids in ruminant feed contribute to digestive metabolism, the use and amount of protein intake.

The percentage of neutral detergent fiber (NDF) reveals a positive correlation with ADF (r = 0.92), LIG (r = 0.46), HEM (r = 0.97), CEL (r = 0.90) PC (r = 0.42) and DM (r = 0.75), and negative with NFC (r = -0.94). Regarding the fiber percentage in acid detergent (ADF) are observed positive correlations of LIG (r = 0.54), HEM (r = 0.82), CEL (r = 0.95), PC (r = 0.38) and DM (r = 0.81), on the other hand negative associations are highlighted with NFC (r = -0.87). The amount of forage fibers is essential for the rumen dynamics and defines the animal sacies point influences the protein utilization, and nutritional balance efficiency (Lazzarini *et al*., 2009).

The lignin percentage (LIG) reveals a positive correlation with the HEM (r = 0.36), CEL (r = 0.34) and DM (r = 0.40), and negative with NFC (r = -0.42). The hemicellulose (HEM) shows positive associations with CEL (r = 0.81), TC (r = 0.42) and DM (r = 0.66), and negative with NFC (r = -0.90). Cellulose (CEL) reveals a positive correlation with TC (r = 0.42) and DM (r = 0.83), and negative with NFC (r = -0.83). The formation of lignin, cellulose and hemicellulose are related to forage species, phenological stage and climatic conditions, this character is inversely proportional to the digestibility of ruminants. The mineral material (MM) and crude protein (CP) showed negative correlation (r = -0.87) and (r = -0.48) respectively, the TC character.

Phenotypic associations of cause and effect were made by fixing the crude protein percentage (PTN) as the dependent character and the other characters as explanatory. The wheat genotypes with double purpose when subjected to the first cut (Table 2) shows the percentage of character lipids direct effect intermediate and negative to the main character. Indirect effects are evidenced low and positive characters with ADF, CEL, MM, TC and DM, as well as low and negative effect on the MV character.

The wheat genotypes with dual purpose to reveal high dry matter yields per hectare increment the establishment of digestible and structural fibers such as cellulose, in contrast, higher proportions of minerals and total carbohydrates are associated with plant tissue. Under these conditions, the lipid ratios are inverse to the protein forage percentage. The selection of genotypes suitable for fodder scope should be grounded to the high yield of dry mass, high protein proportion and acceptance by animals (Pariz *et al*., 2010). The total correlation is revealed (r = 0.15) low and positive, and justifies that the direction and magnitude are assigned to the explanatory characters.

The proportions in a fibrous forage are composed of slow digestion carbohydrates, is required to regulate the amount of food eaten, chewing, salivation and rumination (Branco *et al*., 2011). The percentage characters of neutral detergent fiber (NDF) and acid detergent fiber (ADF) show a direct effect (Table 2) low and negative to CP. The NDF character reveals low and negative indirect effects with NFC. In contrast, the ADF character shows indirect effect intermediate and positive, low and positive with LIP and GM, respectively. high and negative indirect effects are evident with LIG, low and negative via CEL, MM, TC, NFC and DM.

The associations between forage and bromatologic characters show that genotypes of greater magnitude protein in the plant tissue, should show a lower proportion of soluble fibers, structural fibers and lipid constitution, however, more minerals, total carbohydrate and non-fibrous, and high yield dry matter per hectare. The total correlation is evident (r =-0.57) and (r =-0.55) and intermediate negative for NDF and ADF respectively. Studies Maranhão *et al*. (2009) show that the bromatological quality of forage is closely related to higher proportions of crude protein and lower magnitude fibers.

Table 2: Estimated phenotypic direct and indirect effects in eleven forage and bromatologic traits on the crude protein percentage (CP), from five wheat genotypes with double-purpose, subject to the first cut, Frederico Westphalen - RS, 2015.

Effects	Explanatory Variables										
	LIP	NDF	ADF	LIG	HEM	CEL	MM	TC	NFC	GM	DM
Direct	-0.70	-0.13	-0.14	-0.10	-0.13	-0.37	-0.27	0.32	0.23	0.19	-0.26
Ind.via LIP [(1)]	-	0.08	0.59	0.54	-0.40	0.54	0.41	-0.35	-0.23	0.50	0.51
Ind.via NDF	0.01	-	-0.03	-0.07	-0.09	-0.01	-0.03	0.03	0.12	-0.12	0.03
Ind. via ADF	0.11	-0.04	-	-0.13	0.07	-0.13	-0.08	0.07	0.06	-0.08	-0.12
Ind.via LIG	0.07	-0.05	-0.95	-	0.02	-0.08	-0.05	0.04	0.06	-0.05	-0.06
Ind.via HEM	-0.07	.08	0.06	0.02	-	0.08	0.03	-0.03	0.05	0.05	0.11
Ind.via CEL	0.29	-0.04	-0.36	-0.32	0.23	-	-0.25	0.21	0.13	-0.23	-0.35
Ind.via MM	0.16	-0.07	-0.17	-0.16	0.07	-0.18	-	0.27	0.18	-0.26	-0.13
Ind.via TC	0.16	-0.07	-0.16	-0.15	0.07	-0.18	-0.32	-	0.20	-0.30	-0.12
Ind.via NFC	0.07	-0.21	-0.10	-0.15	-0.10	-0.08	-0.15	0.14	-	-0.11	0.00
Ind.via GM	-0.14	0.01	0.11	0.09	-0.08	0.11	0.18	-0.18	-0.09	-	0.09
Ind.via DM	0.19	0.06	-0.23	-0.17	0.22	-0.24	-0.12	0.10	-0.00	-0.13	-
Total (r)	0.15	-0.57	-0.55	-0.62	-0.11	-0.59	-0.69	0.66	0.75	-0.42	-0.33
Determination coefficient			0.94								
Value of K used in the analysis			4.87								
Effect of the residual variable			0.24								
Determinant of the matrix			6.51								

[(1)] LIP: lipids percentage; NDF: fiber percentage of neutral detergent fiber; ADF: fiber percentage in acid detergent fiber; LIG: lignin percentage; HEM: percentage of hemicellulose; CEL: cellulose percentage; MM: mineral material percentage; CP: crude protein percentage; TC: total carbohydrate percentage; NFC: percentage of non fibrous carbohydrates; GM: green mass yield per hectare; DM: dry matter yield per hectare.

The cell constitution of a forage shows eminent importance, because the cell wall is composed of cellulose fractions, hemicellulose and lignin, the interaction of these parts determines the digestibility of forage (Fernandes *et al*., 2009). The percentage of cellulose, hemicellulose and lignin show low direct and negative effects to the CEL (Table 2).

The indirect effects of characters LIG and CEL, observed intermediate and positive with LIP, low and negative with the MM characters, CT, CNF and MS. In contrast indirect effects of HEM character proves to be negative and intermediate, and low and positive with CEL and MS. Genotypes dual-purpose wheat subjected to the first cut, when selected for increased forage efficiency must consider the increase in the proportion of structural polysaccharides, in the cell wall, primarily cellulose and lignin, resulting in decrease of the protein and starchy carbohydrates, these components being of interest to forage area. Total correlations are revealed (r = -0.62), (r = -0.52) and (r = -0.10) negative for LIG, HEM and CEL respectively.

The forage plant has become essential for nutrient dynamics, where the minerals present in the soil are carried and accumulated in plants, and subsequently made available to the animals by forages (Heringer and Jacques, 2002). Direct effect low and negative percentage of mineral material (MM) is revealed to the CP (Table 2). And intermediaries and indirect positive with LIP and low and positive with GM low and negative indirect effects are expressed to the characters CEL, CT and DM. Phenotypic associations reveal that the selection of genotypes with high dry matter production, evidenced reduction in the accumulation of minerals in tissues, and increases the protein composition, and structural starchy carbohydrates. The total correlation is revealed (r = -0.69) and intermediate negative.

Carbohydrates are characterize as polysaccharides of fibrous and non-fibrous fraction. The fiber ratio meets fibers and cell wall constituents, if not comprise fibrous amides and sugars. The interaction between structural and non-structural polysaccharides contributes the ingestion, chewing, salivation and functionality of the rumen (Wanderley *et al*., 2002). The percentage of total carbohydrates (TC) and non-fibrous (NFC) reveal direct effect low and positive to the CP (Table 2). Low and positive indirect effects with FDN, CEL, MM and DM, low and negative with LIP and GM.

When proceeding with the indirect selection in wheat dual purpose for high protein proportion and forage yield, the interrelations between the characters bromatologic make possible obtaining superior individuals in amylaceous carbohydrates and structural, as well as adequate fraction of fibers and minerals in plant tissue. The total correlation is revealed (r = 0.66) and (r = 0.75) and intermediate positive for TC and characters NFC respectively.

The green mass per hectare yield (GM) shows direct effect low and the positive CP (Table 2). Indirectly observe intermediate and positive effect with LIP and low and negative with the NDF characters, CEL, MM, NFC, TC and DM. Indirect selection for genotypes with high green mass production in the first, reveal an increase in protein and lipid fraction of forage, however, is evident reduction of fibrous proportions, minerals, structural and starchy polysaccharides. The total correlation is revealed (r = -0.42) negative intermediate, the inverse relationship is expressed between the GM and the CP is justifiable because of the large number of negative indirect effects involved in the character of the explanation.

The yield of dry mass per hectare (DM) discloses low direct effect and negative to the character CP (Table 2). The indirect effects are evidence intermediate and positive to the LIP, low and positive with HEM. In contrast, low and negative indirect effects are express with FDA, CEL, MM and TC. The selection to be directed towards genotypes with high dry matter yield in the first cut, will result in lower evidence of protein, mineral fraction, and non-structural carbohydrates, and increased hemicellulose and lipids. The total correlation is revealed (r = -0.33) low and negative.

Phenotypic associations for wheat genotypes with double purpose when subjected to the second cut (Table 3), reveal low and negative direct effect of the percentage of lipids (LIP) to CP. Indirect effects prove to be low and positive with LIG and CEL, low and negative with GM and DM. Genotypes dual purpose wheat submitted to the second cut, reveal protein fraction inversely proportional to the lipid with lower forage yields, increases of structural polysaccharides such as cellulose and lignin. The number of cuts because the extension of the growing season forage, reduced digestibility, modifies the cytoplasmic organization reduces the protein fraction, lipid and starchy (Primavesi *et al*., 2001). The total correlation is revealed (r = -0.17) low and negative.

The fiber percentage of neutral detergent fiber (NDF) and acid detergent fiber (ADF) reveal low and negative direct effects will CP (Table 3). The indirect effects are present low and positive for GM and DM, low and negative with HEM, CEL, TC and NFC. Indirect selection of genotypes for high crude protein in the second cut may be preceded by the characters linked to the yield of green mass and dry, however, obtain plants with less fiber, and the starchy polysaccharides.

Studies by Kurek *et al*. (2001) show that indirect selection is an effective tool for genetic improvement of the crop, for assisting in the selection of characters difficult to measure, highly influenced the environment and low heritability. The total correlation was revealed (r = -0.76) and (r = -0.61) and intermediate negative. The magnitudes of the correlations were established by Carvalho *et al*. (2004) defining as zero (r = 0.00), weak or low (r = 0.00 to 0.30), middle or intermediate (r = 0.30 to 0.60), and strong or high (r = 0.60 to 1.00).

In relation to structural polysaccharides of the cell wall, lignin percentage (LIG) shows direct effect low and positive to the CP (Table 3), low and negative indirect effects are expressed with LIP and TC. The total correlation is revealed (r = -0.30) low and negative, showing that the direct effects observed are spurious. The percentage of hemicellulose (HEM) and cellulose (CEL) show low direct and negative effects to CP character. Indirectly observed intermediate and positive effect with DM, low and positive with GM. low and negative indirect effects are observed the characters NDF, ADF, TC and NFC.

Selection for a genotype with high forage yield both green mass and dry mass in the second cut, allow to obtain high crude protein, less fiber, structural polysaccharides such as cellulose and hemicellulose, and starchy carbohydrates. Total correlations of characters HEM and CEL are evident (r = -0.82) and (r = -0.57) high and intermediate, both being negative, respectively.

The percentage of mineral material (MM) shows direct effect null the main character (Table 3). Vencovcky and Belly (1992) state that zero direct effects make the character's response in full correlation is attribute to indirect effects. The indirect effects prove to be low and positive with NDF, ADF, HEM, CEL, TC, low and negative with LIG and DM. Phenotypic associations in the second section shows that the mineral constitution does not influence the character crude protein, but the increment of fiber, structural polysaccharides, starchy carbohydrates contribute favorably to inorganic proportions tissue. The total correlation is revealed (r = 0.49) and intermediate positive.

The total carbohydrate (TC) are composed of lipid proportions, protein, minerals, fibrous, structural polysaccharides, starch and sugars. Thus, there is a direct effect low and negative to the CP (Table 3). Indirect effects prove to be low and positive with LIG and DM, low and negative with NDF, ADF, CEL, MM and NFC. Indirect selection for crude protein and forage yield may result in reducing the proportions of structural carbohydrates, starchy, and fiber.

Table 3: Estimated phenotypic direct and indirect effects in eleven forage and bromatologic traits on the crude protein percentage (CP), from five wheat genotypes with double-purpose, subject to the second cut, Frederico Westphalen - RS, 2015.

Effects	Explanatory Variables										
	LIP	NDF	ADF	LIG	HEM	CEL	MM	TC	NFC	GM	DM
Direct	-0.23	-0.26	-0.14	0.25	-0.35	-0.23	-0.01	-0.26	0.21	0.14	0.55
Ind.via LIP [1]	-	0.07	0.08	-0.13	0.05	0.13	0.02	0.03	-0.10	0.18	0.18
Ind.via NDF	0.08	-	-0.25	-0.09	-0.26	-0.24	0.19	-0.24	0.23	-0.20	-0.17
Ind. via ADF	0.05	-0.13	-	-0.05	-0.12	-0.13	0.11	-0.13	0.09	-0.10	-0.10
Ind.via LIG	0.14	0.08	0.10	-	0.07	0.02	-0.20	0.14	0.00	-0.03	-0.00
Ind.via HEM	0.08	-0.34	-0.30	-0.09	-	-0.29	0.20	-0.29	0.32	-0.26	-0.18
Ind.via CEL	0.14	-0.21	-0.22	-0.02	-0.19	-	0.14	-0.20	0.18	-0.20	-0.18
Ind.via MM	0.00	0.00	0.01	0.01	0.00	0.00	-	0.01	-0.00	0.00	0.00
Ind.via TC	0.03	-0.24	-0.25	-0.15	-0.21	-0.22	0.24	-	0.15	-0.15	-0.14
Ind.via NFC	0.09	-0.18	-0.15	0.00	-0.20	-0.16	0.06	-0.12	-	-0.18	-0.13
Ind.via GM	-0.11	0.11	0.10	-0.02	0.10	0.12	-0.04	0.08	-0.12	-	0.13

Ind.via DM	-0.44	0.35	0.40	-0.00	0.29	0.44	-0.23	0.30	-0.33	0.50	-
Total (r)	-0.17	-0.76	-0.61	-0.30	-0.82	-0.57	0.49	-0.70	0.65	-0.31	-0.01
Determination coefficient			0.95								
Value of K used in the analysis			5.25								
Effect of the residual variable			0.21								
Determinant of the matrix			5.77								

(I) LIP: lipids percentage; NDF: fiber percentage of neutral detergent fiber; ADF: fiber percentage in acid detergent fiber; LIG: lignin percentage; HEM: percentage of hemicellulose; CEL: cellulose percentage; MM: mineral material percentage; CP: crude protein percentage; TC: total carbohydrate percentage; NFC: percentage of non fibrous carbohydrates; GM: green mass yield per hectare; DM: dry matter yield per hectare.

Thus, benefits are obtain with a high bromatological quality of fodder production genotype, suitable digestibility, low proportions of cellulose and hemicellulose. Knowledge of protein proportions and present carbohydrates in forage favors the ruminal dynamic, increases the efficiency of microbial flora, and improving the utilization of food consumed (Malafaia *et al*., 1998). The total correlation is revealed (r = -0.70) and intermediate negative.

The percentage of non-fiber carbohydrates (NFC) shows direct effect low and positive to the CP (Table 3). Indirect effects prove to be low and positive with NDF, HEM, CEL, and TC, low and negative with LIP, MV and DM. In the second cutting indirect selection genotypes with high proportion of non-fibrous carbohydrates, allows increasing the crude protein, but reduces the potential fodder for both green mass and dry genotypes for the dual purpose. The total correlation is revealed (r = 0.65) and intermediate positive. Green mass yield per hectare (GM) and dry matter per hectare (DM) reveal direct effects low and intermediate to both positive respectively, the CP (Table 3). Low and positive indirect effect with LIP, low and negative with NDF, ADF, HEM, CEL, TC and NFC. The indirect selection in the second cut can be carried out to a high potential genotypes feed both green mass when dry, and indirectly obtain an increase of crude protein, by contrast, fewer fibers, structural polysaccharides and carbohydrates are obtained. The total correlation is revealed (r = -0.31) low and negative for GM, and zero (r = -0.01) for MS. The results expressed as the correlation between the DM and CP character does not reveal no associations but indicates non-linear response between the characters (Cruz *et al*., 2004).

The genotypes dual-purpose wheat when subjected to the third section, show low and negative direct effect of the percentage of lipid (LIP) to the CP (Table 4). Low and indirect positive effects are observed with MM, TC and NFC, low and negative ADF and CEL. Indirect selection through lower lipid ratio shows increased protein and starchy fraction, but restricts the proportions of structural fibers and polysaccharides.Studies by López *et al*. (2005) show that lipids are important to ruminants are sources of essential fatty acids, vitamins and energy, where the lipid fraction is composed of simple lipids, phospholipids, galactolipídios and some pigments. The total correlation is revealed (r = -0.27) low and negative.

The percentage of neutral detergent fiber (NDF) shows direct effect low and negative to the CP (Table 4). Indirect effects are evidenced low and negative with HEM, CEL, MV and DM. The total correlation is revealed (r = -0.65) and intermediate negative. As for acid detergent fiber (ADF) observed direct effect low and positive to the CP (Table 4). Indirect effects prove to be low and positive with LIP and CEL, low and negative with TC. The total correlation revealed (r = -0.08) no responses between the dependent character and explanatory characters. Indirect selection strategy through the NDF and ADF ratios are not feasible.

The characters lignin (LIG) and cellulose (CEL) revealed low positive and direct effects, however, hemicellulose (HEM) shows direct effect low and negative to the CP (Table 4). The LIG reveals low and negative indirect effects with NDF, MM and TC. As for HEM are observe low and negative indirect effects with NDF, MV and DM. The CEL has an indirect effect via down and positive LIP, low and negative with TC and NFC. Indirect selection to increase the crude protein in plant tissue becomes a viable strategy by hemicellulose character, in contrast, results in the decrease of forage potential. Total correlations of characters LIG HEM and CEL reveal (r = -0.55), (r = -0.71) and (r = 0.52) intermediate and negative, respectively. Where each structural polysaccharide presents differentially associated with forage and bromatologic characters. The percentage of mineral material (MM) shows direct effect low and positive to the CP (Table 4). Low and positive indirect effects are reveal with TC and NFC, low and negative with LIP and CEL. For the third cut indirect selection can be made to through the mineral material character, being beneficial to the growth of proteins, structural carbohydrates and starchy. The total correlation is revealed (r = 0.41) and intermediate positive.

Table 4: Estimated phenotypic direct and indirect effects in eleven forage and bromatologic traits on the crude protein percentage (CP), from five wheat genotypes with double-purpose, subject to the third cut, Frederico Westphalen - RS, 2015.

Effects	Explanatory Variables										
	LIP	NDF	ADF	LIG	HEM	CEL	MM	TC	NFC	GM	DM
Direct	-0.16	-0.15	0.13	0.12	-0.19	0.37	0.22	-0.36	-0.28	0.13	0.19
Ind.via LIP (1)	-	-0.02	0.12	0.01	-0.05	0.15	-0.10	0.08	0.09	-0.00	0.02
Ind.via NDF	-0.02	-	-0.08	-0.11	-0.14	0.04	0.00	-0.03	0.03	0.14	0.14
Ind. via ADF	-0.10	0.07	-	0.07	0.04	0.08	-0.05	0.06	0.02	-0.09	-0.06
Ind.via LIG	-0.01	0.09	0.06	-	0.08	-0.00	-0.05	0.06	0.02	-0.06	-0.05
Ind.via HEM	-0.07	-0.19	-0.06	-0.13	-	0.09	-0.01	-0.02	0.06	0.17	0.17
Ind.via CEL	-0.35	-0.10	0.24	-0.00	-0.18	-	-0.16	0.11	0.16	0.03	0.11
Ind.via MM	0.13	-0.00	-0.09	-0.10	0.02	-0.09	-	-0.21	-0.21	-0.00	-0.04
Ind.via TC	0.18	-0.08	-0.17	-0.20	-0.04	-0.10	0.35	-	-0.32	0.06	0.00
Ind.via NFC	0.16	0.06	-0.06	-0.05	0.09	-0.12	0.27	-0.25	-	-0.08	-0.12
Ind.via GM	0.00	-0.13	-0.09	-0.07	-0.12	0.01	-0.00	-0.02	0.03	-	0.13
Ind.via DM	-0.03	-0.18	-0.09	-0.09	-0.18	0.05	-0.04	-0.00	0.08	0.19	-
Total (r)	-0.27	-0.65	-0.08	-0.55	-0.71	0.52	0.41	-0.61	-0.29	0.50	0.50
Determination coefficient			0.96								
Value of K used in the analysis			5.44								
Effect of the residual variable			0.18								
Determinant of the matrix			2.05								

(1) LIP: lipids percentage; NDF: fiber percentage of neutral detergent fiber; ADF: fiber percentage in acid detergent fiber; LIG: lignin percentage; HEM: percentage of hemicellulose; CEL: cellulose percentage; MM: mineral material percentage; CP: crude protein percentage; TC: total carbohydrate percentage; NFC: percentage of non fibrous carbohydrates; GM: green mass yield per hectare; DM: dry matter yield per hectare.

The total carbohydrate (TC) and non-fiber (NFC) shows low direct and negative effects to the CP (Table 4). Indirectly show low and positive effect to the character CEL, low and negative with MM. The crude protein increase in the third cut indirect selection based on both the total carbohydrates as the non-fibrous, has no satisfactory results. Total correlations for the TC character (r = -0.61) and NFC (r = -0.29) are revealed intermediate and low, both being negative, respectively.

The green mass yield per hectare (GM) and dry mass per hectare (DM) show low direct and positive effects on the CP (Table 4). Indirectly low and positive effects are observed with NDF, HEM and CEL, low and negative via NFC. In the third cut, we observe the feasibility of applying indirect selection through forage yield as greener as dry mass flocking a high forage potential genotype, high protein fraction, and higher levels of court. The total correlation to GM characters and MS is present (r = 0.50) and (r = 0.50) and positive intermediate.

The cutting management affected the magnitude of the effects for all the characters, as to the meaning of the associations, the LIP characters, NDF, HEM and GM kept the sense of independent cutting management effects. The first cut affected the sense of the characters LIG, TC and DM, in contrast, the third cut reveals changes in the direction of associations with FDA, CEL, MM and NFC.

The indirect selection of dual-purpose wheat to increase crude protein, must be grounded in the associations between characters of forage interest and bromatological, and consider cutting employee management. Phenotypic estimates of characters linked to the crude protein percentage show high coefficients of determination and lower residual effects, these associations are reliable and can be used as a tool for indirect selection in breeding. This work presents a great contribution to agricultural science and especially the genetic improvement of wheat crop with dual purpose, it reveals that the important interrelationships between morphological a characters and bromatological in each cutting management in the same way, evidence criteria for employment indirect selection of secondary determinants a characters to increase crude protein in wheat forage dual purpose.

Conclusions:

The indirect selection increase the percentage of crude protein in the first cut may be based on percentage of total carbohydrates, non-fibrous and green mass yield per hectare.

The second cut provides indirect selection with a percentage of non-fibrous carbohydrates, green mass yield and drought per hectare.

The increase of crude protein in the third cut may be obtain through indirect selection to the percentage of cellulose, mineral material, green mass yield and dry per hectare.

Indirect selection through forage and bromatologic character can be successful, since it considers the effect assigned to each cutting management.

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