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RELATIVE POTENCY IN REDUCED MULTIVARIATE LINEAR MODEL. PART II – APPLICATION

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Summary

Estimation of relative potency of nitrogen fertilization administered in yielding of Amilo and Esprit rye varieties is presented. This estimation has been done for traits of milling product measured on grains getting for different doses of nitrogen applicated in different time of vegetation. Influence of three types of nitrogen application on milling product, considered as test preparations, has been compared to a standard nitrogen application. Testing proper hypotheses and estimation of potencies of nitrogen fertilization have been conducted according to theory presented in Part I of the paper.

Keywords and phrases: Amilo and Esprit rye varieties, grain milling process, multivariate responses, nitrogen fertilization, reduced model, relative potency

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1. Introduction

In many agricultural experiments impact of nitrogen fertilization on growing plant is investigated. In general, the influence of different doses of fertilizers is measured by different traits. Frequently, the main traits are strictly connected with yielding of plants (Hanusz, Jędruszczak, 1999, Hanusz et al., 2003). From the other side, influence of nitrogen on traits valuable in food industry should also be considered (Laskowski and Zdybel, 2003; Zdybel, 2006). In the paper we focus on traits of rye grain considered in milling process. Based on measurements of these traits, comparison of influence of different nitrogen administration on Amilo and Esprit rye varieties is regarded. In Section 2 we describe test and standard nitrogen fertilization and illustrate their influence on milling traits. In Section 3 we present calculation results connected with estimation of the potency of nitrogen fertilization in the model reduced to chosen traits and for chosen test preparations. Some concussion remarks are presented in Section 4.

2. Analysis of milling traits of rye grain in full model

To assess comparison of impact of different type of nitrogen fertilization on milling traits of rye grain we use estimation of relative potency of preparations presented in Part I (Olejnik, Hanusz, 2011). We consider the measurements of grains obtained for different doses of nitrogen, administered in different time of plant vegetation. As a standard preparation S and test preparations T_1, T_2 and T_3 we consider as follows:

- a standard preparation S indicates nitrogen administered before sowing in doses 30, 60 and 90 kilogram per hectare ($kg{\cdot}ha^{-1}$),
- a test T_1, nitrogen administered in the dose 30 $kg{\cdot}ha^{-1}$ before sowing plus 0 or 30 $kg{\cdot}ha^{-1}$ after beginning of vegetation,
- a test T_2, nitrogen administered in the dose 30 $kg{\cdot}ha^{-1}$ after the third knot created plus 30 or 60 $kg{\cdot}ha^{-1}$ after beginning of vegetation,
- a test T_3, nitrogen administered in the dose 90 $kg{\cdot}ha^{-1}$ with a regulator before sowing plus 0 or 30 $kg{\cdot}ha^{-1}$ after the third knot created.

To statistical analysis we took into account six traits describing grain milling, namely, mean particle size (y_1, [mm]), specific milling energy (y_2, [$kJ{\cdot}kg^{-1}$]), milling efficiency index (y_3, [$kJ{\cdot}kg^{-1}$]), energy utilization index (y_4, [$kJ{\cdot}m^{-2}$]), flour extract (y_5, [%]), and Sokolovsky index (y_6, [$kJ{\cdot}kg^{-1}{\cdot}mm^{0.5}$]). All measurements of traits were done in three trials at the Department of Equipment Operation and Maintenance in the Food Industry, University of Life Sciences in Lublin. Plots of regression lines for measurements of traits opposite to log of total doses for Esprit and Amilo rye varieties are illustrated in Figure 1 and 2, respectively. The displays in Figure 1 show that almost everywhere the regression lines for each trait of milling Esprit grain for test T_1, T_2 and T_3 are not parallel to the standard preparation S. This indicates that different doses and types of nitrogen fertilization have differentiated impact on grain milling traits. This fact has been confirmed by the rejection of a null hypothesis that vectors of slopes for test preparations were equal to the vector of slopes for the standard preparation, i.e. $H_{\boldsymbol{\beta}}^{0}:(\boldsymbol{\beta}_{T_1}=\boldsymbol{\beta}_S)\wedge(\boldsymbol{\beta}_{T_2}=\boldsymbol{\beta}_S)\wedge(\boldsymbol{\beta}_{T_3}=\boldsymbol{\beta}_S)$. The hypothesis $H_{\boldsymbol{\beta}}^{0}$ was tested against the alternative that some slopes vectors of test preparations were not equal to the vector of slopes for the standard preparation, using *Lambda Wilks* test statistic (3.2) of Part I (Olejnik, Hanusz, 2011). Calculated *p*–value has been greatly less than fixing significance level 0.05. It means that influence of considered types of nitrogen fertilization on milling traits of rye grain of Esprit variety is not similar, so the relative potencies of test preparations T_1, T_2 and T_3 should not be estimated with respect to the standard preparation S.

The regression lines for milling traits of rye grain of Amilo variety presented in Figure 2 indicate parallelism at least for some traits. However, for all considered traits in the responses for nitrogen fertilization, the hypothesis about parallelism has also been rejected on significant level 0.05. Then, identically to conclusion about the milling traits of rye grain of Esprit variety, we were not allowed to test the hypothesis about potencies of all test preparations relative to one standard simultaneously for all traits in responses. However, we could restrict our attention to some selected traits and test preparations.

3. Analysis of milling traits of rye grain of Amilo variety in reduced model

For all traits of milling grain of Esprit and Amilo rye varieties the hypothesis about similarity of comparing nitrogen fertilization was rejected. In a further considerations we restrict our attention to Amilo variety for data in reduced model containing some chosen traits and test preparations. To get more information about the milling grain traits the correlation matrix was calculated based on 27 observations (3 doses for standard fertilization, 2 doses for each test fertilizations T_1, T_2 and T_3 and 3 grains for each dose). The results are enclosed in Table 1.

Table 1. Correlations between milling grain traits of Amilo variety

Corr(y_i,y_j)	y_1	y_2	y_3	y_4	y_5	y_6
y_1	1	–0.776	0.996	0.644	–0.773	–0.429
y_2	–0.776	1	–0.714	0.982	1	0.903
y_3	0.996	–0.714	1	–0.570	–0.711	–0.344
y_4	0.644	0.982	–0.570	1	0.983	0.967
y_5	–0.773	1	–0.711	0.983	1	0.905
y_6	–0.429	0.903	–0.344	0.967	0.905	1

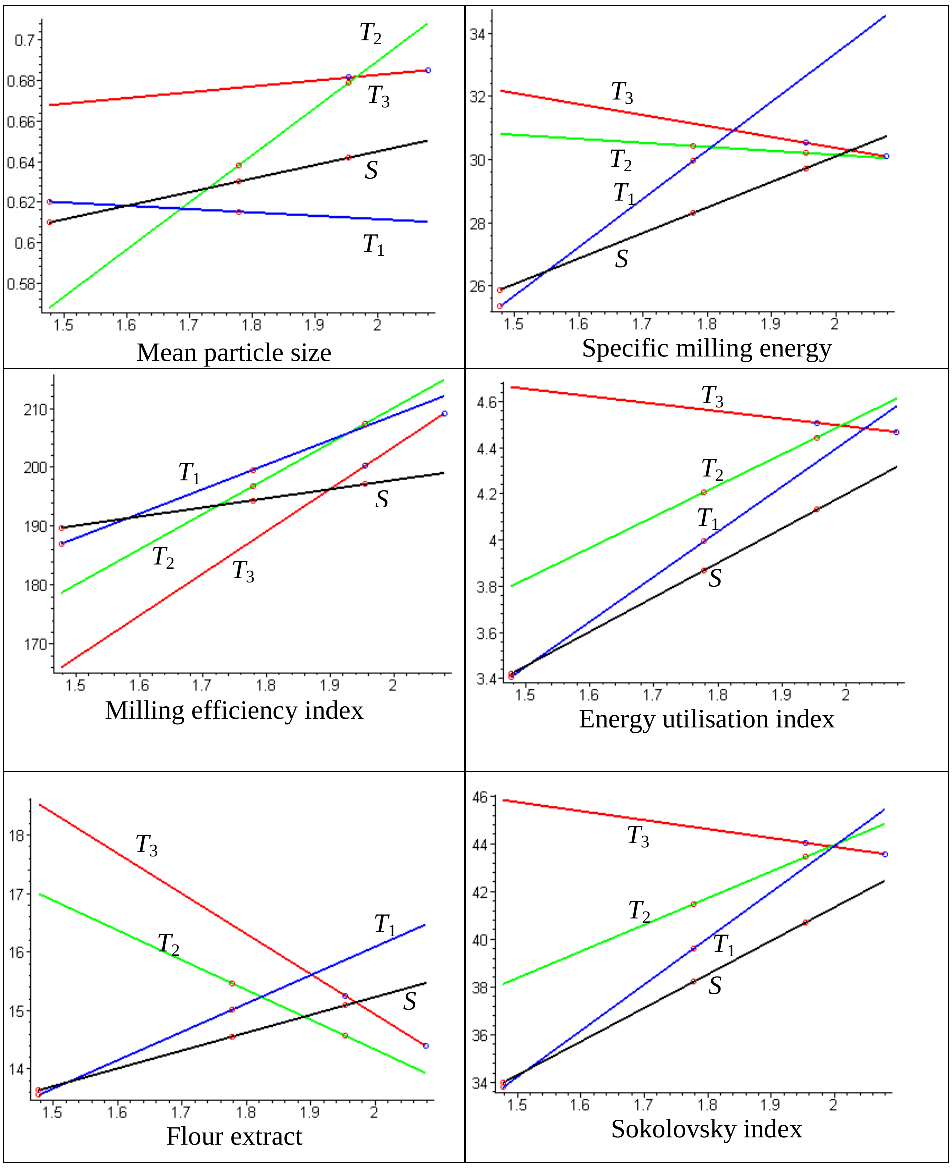

Fig. 1. Regression lines for milling traits of rye grain of Esprit variety opposite to log of total doses

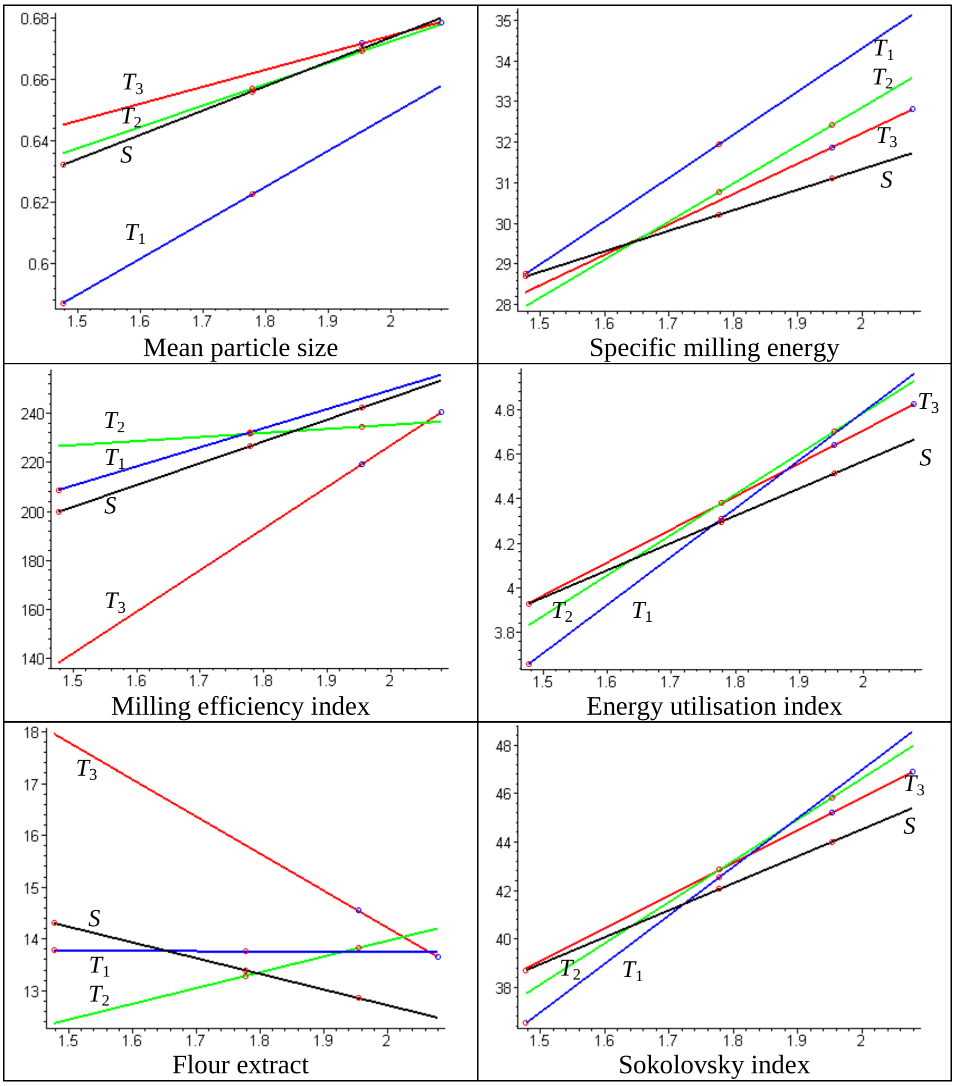

Fig. 2. Regression lines for milling traits of rye grain of Amilo variety opposite to log of total doses

It is interesting to note that almost all traits are mutually significantly correlated (on significant level 0.05). Maximal correlation appeared between specific milling energy (y_2) and flour extract (y_5), so in further analysis we should consider only one of them. Considering all preparations, even for chosen traits, the hypothesis $H_{\boldsymbol{\beta}}^0 : \left(\boldsymbol{\beta}_{T_1} = \boldsymbol{\beta}_S\right) \wedge \left(\boldsymbol{\beta}_{T_2} = \boldsymbol{\beta}_S\right) \wedge \left(\boldsymbol{\beta}_{T_3} = \boldsymbol{\beta}_S\right)$ has always been rejected. This forced us to regard comparison between one test preparation relative to the standard preparation for any chosen two traits. When the hypothesis $H_{\boldsymbol{\beta}}^0 : \mathbf{C}\boldsymbol{\Theta}_1 = \mathbf{0}_{t^* \times p}$ in (4.2) of Part I, where t^*=1 and $\mathbf{C} = [0,0,-1,1]$ was not rejected then the hypothesis $H_{\boldsymbol{\mu}^*}^0 : \mathbf{C}_{\boldsymbol{\mu}^*}\tilde{\boldsymbol{\Theta}}_1 = \mathbf{0}_p$ in (4.4) of Part I has been tested, where $\mathbf{C}_{\boldsymbol{\mu}^*} = [-1,1,\mu_i]$, and μ_i denotes the log relative potency of the i–th test preparation ($i=T_1,T_2,T_3$), using *Lambda Wilks* test statistic of the form (5.6) of Part I (Olejnik, Hanusz, 2011).

For simplicity we do not present the test statistics for hypotheses $H_{\boldsymbol{\beta}}^0$ and $H_{\boldsymbol{\mu}}^0$ as they take different forms, strictly connected with the selected test preparations and chosen traits. The computing results for testing above hypotheses, as well as the estimates of relative potency of the test nitrogen fertilization with respect to the same standard nitrogen fertilization are enclosed in Table 2. Let us note that some rows of Table 2 enclosed the estimates of relative potencies even for rejected hypothesis $H_{\boldsymbol{\beta}}^0$. For significant level 0.05 both hypotheses were accepted only in four cases (denoted by bolds). In these cases the test fertilizations were more potent then the standard fertilization. For example, considering mean particle size (y_1) and specific milling energy (y_2), in the second row we get potency 0.84. It means that to get the same responses y_1 and y_2, the T_2 type of nitrogen fertilization should be applied in 84% of the dose as for the standard nitrogen fertilization. For those traits we were able to estimate jointly T_2 and T_3 with S. It is easy to see that coordinates of the vector of relative potencies are very closed to that estimated separately, namely, $\hat{\boldsymbol{\rho}} = [\hat{\rho}_2, \hat{\rho}_3] = [0.84, 0.85]$ and estimates in separate analysis are equal to $\hat{\rho}_2 = 0.84$ and $\hat{\rho}_3 = 0.82$.

Table 2. Calculation results for chosen milling grain traits of Amilo rye variety

Comparing traits	Comparing preparations	*p*–value		Estimate of relative potency
		$H_{\boldsymbol{\beta}}^0$	$H_{\boldsymbol{\mu}}^0$	
y_1 and y_2	T_1 with S	0.000	Not tested	Not estimated
	T_2 with S	**0.058**	**0.419**	**0.84**
	T_3 with S	**0.796**	**0.565**	**0.82**
	T_2 and T_3 with S	**0.138**	**0.666**	[**0.84, 0.85**]
y_3 and y_4	T_1 with S	0.000	0.046	0.96
	T_2 with S	0.0067	0.347	0.86
	T_3 with S	0.0007	0.000	0.87
y_3 and y_5	T_1 with S	**0.081**	**0.724**	**0.80**
	T_2 with S	0.022	0.449	0.90
	T_3 with S	0.028	0.006	1.27
y_3 and y_6	T_1 with S	0.000	0.120	0.93
	T_2 with S	0.017	0.351	0.86
	T_3 with S	0.008	0.0004	0.93

4. Conclusions

In the paper the estimation method of potency of different ways of nitrogen fertilization with respect to one standard nitrogen fertilization is presented. We showed that for real experimental data, not always the assumptions putting on observations (responses) are fulfilled. Frequently we have to restrict our consideration to the part of valuable data.

In the case of milling rye grain of Amilo and Esprit varieties considered in the paper, model of all data set did not allow to estimate potencies of all types of nitrogen fertilization with respect to one fertilization regarded as standard for all traits of milling properties.

We were able to estimate potency only for some chosen pairs of traits of each test preparation regarding separately relative to the same standard. In that cases we showed that in the majority the test nitrogen fertilization were more potent than standard nitrogen fertilization.

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