Quantitative Population Epigenetics a Catalyst for Sustainable Agriculture

Reinhold Stauß

Ritzebeker Weg 13, 24222 Schwentinental district Klausdorf, Germany, Reinhold.Stauss@web.de

Implications

Ecological intensification of agricultural practices can be a minimum input agriculture with a maximum utilization of the epigenetic potential for a maximum output.

The application of Quantitative Population Epigenetics as a catalyst for sustainable agriculture offers earning opportunities (market segments or business cases) for the existing players in the high-input agriculture in terms of win-win.

For example, agriculture is a major factor in eutrophication of surface waters. By using epigenetically active compounds to switch on yield or stress genes, new crop varieties for low-input agriculture could be developed to improve nitrogen and water use efficiency for cereal production significantly.

Background and objectives

Quantitative Population Genetics (Stauss 1992, Stauss 2012) describes the variability observed in characters due to genetic variation. Quantitative Population Epigenetics describes the variability observed in characters due to factors in the environment -- induced primarily by factors of the farming system.

The “breeder” improves the genotype -- for him environments are "fixed” effects. The farmer strives to intervene in the environment by effecting a specific phenotypic expression, within the norm of reaction inherent in the genotype.

Environments with high-yield potential enable a maximum use of the genetic yield potential -- often resulting in high input agricultural production systems with an overuse of groundwater, natural resources and biodiversity.

The use of Quantitative Epigenetics and the related importance of stress (Steinberg 2011) can be a way out of this impasse. There can be a paradigm shift, away from a maximum input system with a maximum utilization of the genetic potential towards a minimum input system with a maximum utilization of the epigenetic potential, that is, to an optimization of limiting stress factors to achieve maximum results with limited environmental resources. For the agricultural and the food industry there is a need for an ecological intensification of agricultural practices, there is a need for a second green revolution.

Key results and discussion

Ecological intensification of agricultural practices, as defined by Löwenstein (Löwenstein 2012), can be a minimum input agriculture (maximization of $1\text{-}h^2$) with a maximum utilization of the epigenetic potential for a maximum output:

- low input with high output and
- utilization of the genetic potential (inherited characteristics) and the environmental potential or environmental inheritance (acquired characteristics).

This approach offers earning opportunities (market segments or business cases) for the existing players in the high-input agriculture in terms of win-win), especially in utilization of genotype-environment interactions, such as

- nutritional deficiencies and for example use of a genotype-low-nitrogen interaction (low input/high output-varieties, breeding companies),

- bioactive "additives" (regulator-active compounds) to switch on yield genes of nitrogen deficiency (chemical industry, fertilizer industry) and
- drought/seed treatment with anti-apoptotic substances (chemical industry, fertilizer industry, breeding companies, agricultural engineering companies).

The cultural sustainability (values, appreciation, ethics, customs, agriCulture, ...) as unifying element for the environmental, economic and social pillar **is** the (positive) stress (maximization of $1\text{-}h^2$) for a paradigm shift in the behavior of stakeholders (Altner G 1992):

- credibility and awareness, life style issues,
- Corporate Social Responsibility,
- low-input with high-output of food and, for example clean water, biodiversity, landscape, agriCulture, ...,
- win-win situation for the actors of today's intensive agriculture and
- see also the INTERREG IV B Baltic Sea Project Baltic COMPASS example (Heinrich C and Rammert U 2011) and agri-environmental measures.

How work was carried out?

In the 80s Stauss has rewritten parts of University Stuttgart-Hohenheim lecture notes of Prof. Geiger, Prof. Fewson and Mr. Utz concerning quantitative genetics and selection indices analogous to the environmental point of view as "selection of biologically active substances (as ingerdiants of the environment) on the basis of quantitative genetics." The "analog invention" was without test results, unfortunately, it could not be patented, but with Stauss 1992 he succeeded with an "application"-publication for the field of agro-industry. The initial reason of his work at that time was a statement of his superiors at Ciba in Basel that the chemical pesticides and plant regulators industry is the competing sector to breeding.

Recently Stauss realized that he basically had developed a script on "Quantitative Population Epigenetics".

References

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