DEVELOPING SELECTION CRITERIA FOR BREEDING ORGANIC NITROGEN-EFFICIENT POTATO (*Solanum tuberosum*) VARIETIES

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Introduction

The growing season for organic potatoes is, compared to conventionally produced potatoes, relatively short. On the one hand it is limited by late blight (*Phytophthora infestans*) infestation and on the other hand by a low nitrogen supply.
It is generally assumed that late blight infestation is the most important yield reducing factor in organic potato cultivation in Europe (Stöppler et al., 1990; Neuhoff, 2000). In the Netherlands the canopy of the potato crop has to be destroyed at an infestation level of 7% to avoid spread of inoculum to surrounding fields (HPA regulation, 2003). In the case of an early infestation of late blight this means the primary production processes are called to a halt when the tuber bulking rate is on its top. In years with little disease pressure, nitrogen availability is probably the most important yield limiting factor.
The organic sector in the Netherlands refrains from chemical synthetic pesticides and fertilizers. The nutrient management is based on crop rotations, solid and liquid animal manures, green manures and compost (Finckh et al., 2006). The release of nitrogen from most of these fertilizers is slow and highly dependent on soil moisture and soil temperature affecting mineralization processes (van Delden, 2001). Therefore, nitrogen management in organic production systems is very complex. The supply of nitrogen from organic resources is difficult to synchronize with crop demand (Pang and Letey, 2000). Möller et al. (2007) state that, in Germany, nitrogen availability is the most important factor limiting yields in organic potato crops. They developed a model which in total accounted for 73% of the observed variation in yield. Only 25% of the variation could be attributed to the influence of late blight. In contrast, almost half of the variation (48%) could be explained by differences in nitrogen availability. They concluded that in organic farming, yields are mainly limited by nutrient availability in spring and early summer. The organic sector strives to work in closed nutrient cycles. However, organic manure is scarce. Therefore, the nitrogen input in organic production systems is low, compared to the input in conventional production systems. The lack of adequate and stable nitrogen supply leads to agronomic uncertainties. Modern varieties have a poor plasticity in response to variation in nitrogen availability, having small root systems, and require large quantities of nitrogen to maintain vegetative growth and productivity throughout the growing season (Vos, 1997). Such varieties are not adapted to organic growing conditions. The organic farmer prefers varieties with good yield stability, good adaptation to low nitrogen input and a good recovery capacity after a period of nitrogen shortage.

Nitrogen

Nitrogen supply affects an array of physiological processes and morphological traits of the potato crop. These include (1) the rate of canopy development, (2) the rate of leaf appearance, the rate of individual leaf growth, final leaf size, and the life span of individual leaves, (3) the integral of light interception by the crop over time, (4) the rate of photosynthesis, (5) the number of lower and sympodial branches, and (6) the onset of tuberization, final tuber yield and final harvest index (Biemond & Vos, 1992: Ewing & Struik, 1992; Vos & Biemond, 1992; Vos, 1995; Vos & MacKerron, 2000). Nitrogen supply may also affect quality aspects including tuber size distribution, tuber dry matter content, protein content, nitrate content and processing quality (Van Kempen et al., 1996). Much research has been done to assess the yield response of varieties to nitrogen supply under high levels of input. Varieties vary in their response to high nitrogen input. This variation in response

is mostly associated with differences in maturity type (Van Kempen et al., 1996). However, very little quantitative information is available about genotypic differences in response to nitrogen under low levels of. Van Delden (2001) mentioned differences in the sensibility to nitrogen shortages between the varieties Junior and Agria. Also breeders and organic farmers experience large genotypic variation in the response to low levels of nitrogen. The physiological mechanisms explaining these differences and the genetic background are, however, unknown.
Most research programs on nitrogen use in potato focus on the optimization of nitrogen supply and the timing of nitrogen supply in order to reach for each individual variety the highest yield with the best quality. To the best of our knowledge, no research is done on the opposite research question: Given a low nitrogen input, what kind of variety will be able to perform well? To answer that question one has to understand the physiological mechanisms behind nitrogen use efficiency of potatoes under low nitrogen conditions.

Project
The aim of the present project (2008–2011) is to design selection criteria for high nitrogen use efficiency under low nitrogen conditions to support breeding programs for organic potato varieties.

The first step in this research is to identify morphological plant traits that are correlated with nitrogen use efficiency and good performance under low nitrogen conditions. The next step is to translate these traits into cheap, simple and easily applicable selection criteria. We also want to do research on the nitrogen plasticity of varieties. How do they perform after a period of nitrogen shortage? What is their recovery capacity when nitrogen becomes more abundant?

The project started in 2008 with a field experiment to identify morphological plant traits that are associated with high nitrogen use efficiency. Nine varieties known by experience to differ in nitrogen requirement (Agata, Leoni, Biogold, Santé, Bionica, Fontane, Terragold, Agria and Spirit) have been tested at three nitrogen levels (low, medium and high input) on an organic and on a conventional trial field in four replicates. The soil cover is assessed twice a week, whereas leaf area, tuber bulking and nitrogen accumulation in haulm and tubers are measured over time by frequent intermediate harvests. We expect to find some parameters (a to d; see Figure 1) in the soil cover curve that are correlated with nitrogen efficiency under low input conditions.

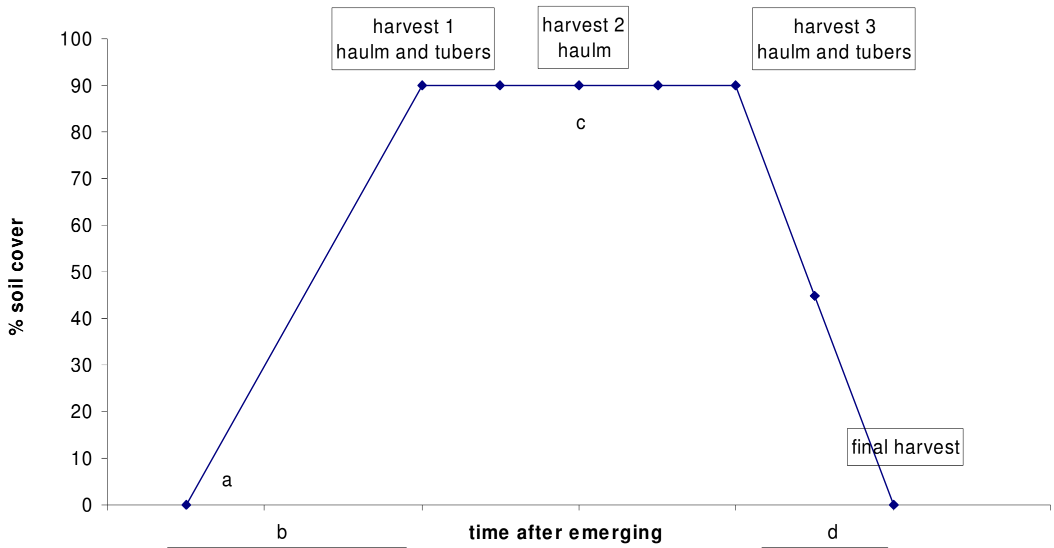

Figure 1. Soil cover curve with the parameters a, b, c and d and time of intermediate harvests (Vos & MacKerron, 2000).
a = rate of soil cover (%/day); b = time to reach maximum soil cover; c = length of period with maximum soil cover; d = time from maximum soil cover to haulm death.

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