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Using the single seed oxygen consumption measurement as a method of determination of different seed quality parameters for commercial tomato seed samples

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Abstract

The aim of this study is to compare different commercial tomato seed samples, using the "Single Seed Oxygen Consumption Measurement" (hereafter called the Q_2) and this in comparison with other classical quality determination methods. All samples were obtained through the local distribution centers. Good correlations were found between some of the obtained Q_2 quality parameters and the germination percentage as well as some different vigor tests (early score and the mean germination time). The Q_2 technology was able to give repeatable data in a relative short timeframe and was able to bring a multi dimensional view onto the seed quality of these samples to the attention of the seed analyst.

Keywords: Germination, Oxygen, Quality, Seed, Tomato

Introduction

Introduction to the "Single Seed Oxygen Consumption Method" (Q_2)

The Q_2 instrument measures the percentage of oxygen in closed micro titer plates, consisting of 24-48-96 wells, on regular time intervals. The purpose of the measurements is to relate oxygen consumption of seeds over time to the quality of the seed lot. Q_2 stands for Quality and Quick, but also stands for O_2 (oxygen), the element on which the whole Q_2 instrument is based upon.

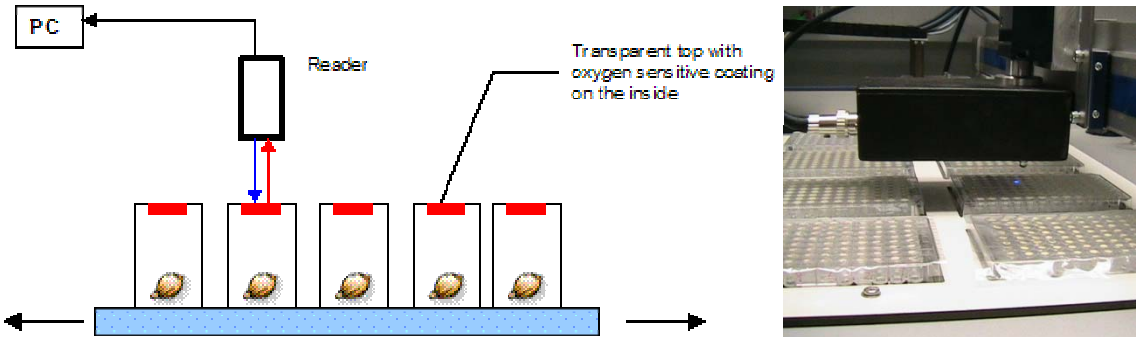

Figure 1. Principle scheme of measurement of oxygen concentration in closed compartments containing imbibed seeds and a picture of the Q_2 instrument in the measuring mode.

A New Era in Seed Quality

The Q_2 Oxygen Sensing Technology is a revolution in seed testing for basic research and commercial operations alike. It provides a fast and accurate measurement of the germination level of a seed lot. In addition, Q_2 data are more robust and defining than traditional germination tests. Depending on the species, the estimated time needed will be between 24 and 120 hours. One will easily determine dead, dormant or actively germinating seeds. Although it currently does not provide specific details on seedling abnormalities, the Q_2 can give quicker and more accurate indications of the vigor and the homogeneity of a seed lot.

Figure 2. After measurement of oxygen consumption for a few days and subsequent removal of the seal, the seeds are often still able to provide seedlings.

Seeds and Oxygen

Germination tests are time consuming. Too often seed lots are sent out without the proper controls. Too many times seeds are processed without adequate quality information for getting the best from the seeds. The Q_2 Instrument can give one results far quicker than a germination test. Moreover, thanks to the latest developments in optical technology for measuring oxygen, the Q_2 Instrument is able to detect seeds where the first stage of germination has been started, since onset of metabolic activity is characterized by an

increased amount of oxygen consumption. Besides a very fast detection of germinating seeds, much more information can be found in the results of this single test. For example, Q_2 Instrument data concerning the dormancy of non-germinating seeds, information about the homogeneity of a seed lot, information concerning different stress related factors, and so much more can be measured.

Q_2 tests can be used as fast and accurate indications of germination under certain conditions. They can be used to detect the maximum germination (correlates to an International Seed Testing Association (ISTA) test) or under various environmental conditions, such as temperature, moisture, and substrates. In the second case, Q_2 tests can be used as a stress test, telling one something about the vigor of seeds. Certain abnormalities may be detected, but only if oxygen consumption is affected. The accuracy of this test depends on the protocol used and of course, the integrity of the sample. The instrument enables one to test large samples (from a single seed to several micro titer plates) and the duration of the test will influence the quality of the results (from a minimum of a single scan to an indefinite period; 48 hours for the most common seeds). The development of protocols for ones seed testing objectives is important and the precision of executing these protocols, such as the application of water, and in certain cases, the substrate application will obviously influence the results as well.

The key innovation to the Q_2 Oxygen Sensing Technology is that oxygen consumption is directly and proportionately related to energy use directly. Thus, a seed's energetic potential can be determined by measuring its oxygen consumption in a simulated field environment. Because of this proportional relationship between oxygen consumption (respiration) and caloric energy consumption (metabolism), robust inferences for a seed's performance in the field can be made. To characterize a greater population or seed lot, measuring respiration and metabolism seed by seed is thus very precise and accurate using the Q_2 Instrument. Measuring energy use can give one new insights on germination and vigor in a single test and in a quick and high quality fashion.

Q_2 values Introduction

Q_2 oxygen data over time, as described above, results in data sets and graphs with tremendous information but are subjective and difficult to use. Therefore ASTEC has developed a set of objective and easy to use values that can be calculated from the Q_2 data directly. This set of values provides everyone, from a seed technician to upper management, a valuable tool to both interface between each other and interpret and manage the data together, ultimately, to critically analyze the quality of the tested samples.

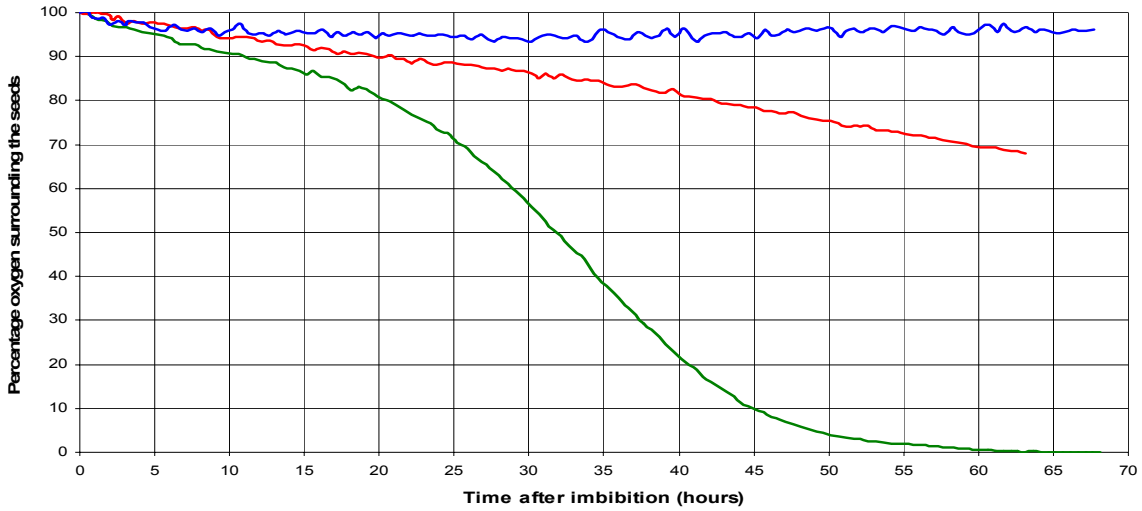

Figure 3. Typical oxygen consumption patterns observed with imbibed seeds of different quality. The percentage oxygen is presented as relative to the initial oxygen levels.

In figure 3 it is clear that the upper line displays no oxygen consumption; this is therefore categorized as a dead seed. The line showing a small and constant amount of oxygen consumption is categorized as a dormant seed. The lower line displays a dramatic increasing in oxygen consumption (which is proportional to energy use, see above); this is therefore categorized as a germinating seed. Note that in this figure, a clear idea concerning the germination quality of this seed lot data was sufficiently available after 30 hours, but that for a complete picture of the seeds, approximately two days were needed. The vigor data splits the germinating seeds in two groups: strong germinators (meaning the seeds that show a sigmoid type of oxygen consumption pattern) and weak germinators (meaning the seeds that show a linear or incomplete oxygen consumption pattern).

We can also look to the different curve characteristics, hereafter called the ASTEC values (Figure 4):

IMT – Increased Metabolism Time
OMR – Oxygen Metabolism Ratio
COP – Critical Oxygen Pressure
RGT – Relative Germination Time
HOM – Homogeneity of the RGT

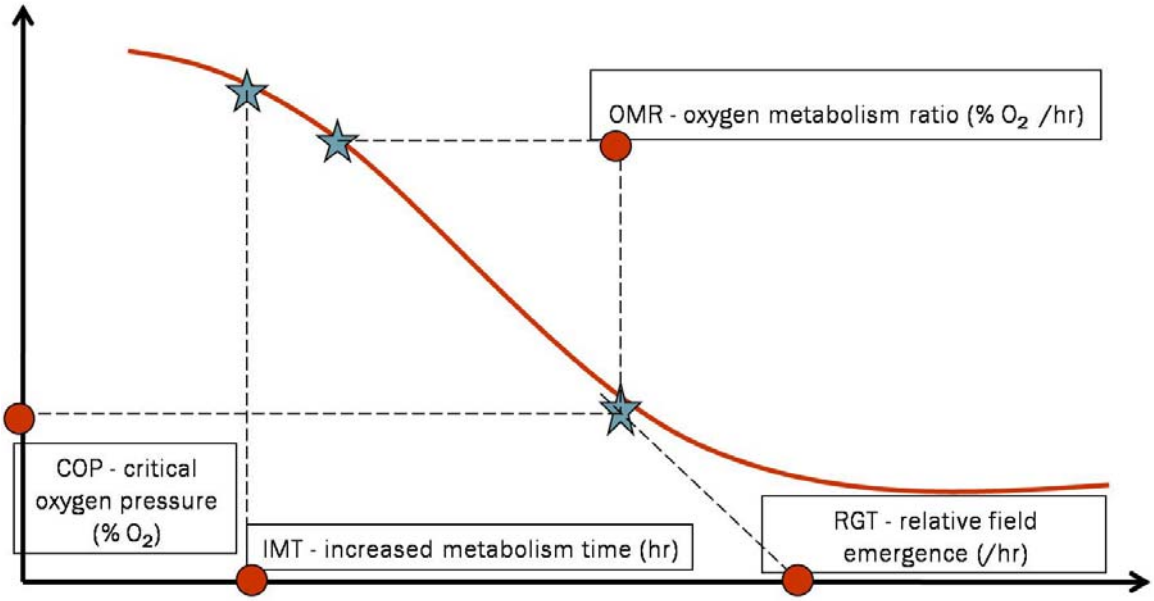

Figure 4. Oxygen consumption pattern with the different Astec values indicated on the curve.

The Increased Metabolism Time (IMT) is the time (in hours) that the seed (or seeds) take to begin increasing their metabolism. This value will be affected by the water permeability of the pericarp, the structure and composition of the coating and/or pelleting layers and the ability of the seeds to imbibe the necessary water to increase their metabolism in the germination process.

The Oxygen Metabolism Rate (OMR) is the maximum amount of oxygen that can be consumed over time by the seed. This rate is expressed as % oxygen per hour. Because there is a direct relationship between the amount of oxygen consumed and the amount of energy used, this rate value is well related to the speed of germination.

The Critical Oxygen Pressure (COP) value is the lowest threshold or amount of oxygen where seeds start to reduce respiration, and thus, metabolism as a response to the lack of oxygen. This value (expressed as oxygen % relative to the initial level) provides an idea of how the seeds will perform under oxygen stressed conditions. Such stress may occur in cold and wet soils, or perhaps when there is a water film created around the seeds or in water saturated pellets and/or coatings.

The Relative Germination Time (RGT) is a value to make inferences about the germination time (or even field emergence) of a seed lot. For seeds undergoing the germination process, the two biological factors which play major roles in the RGT are the IMT and the OMR (time to begin breaking dormancy and rate of metabolic energy use).

The Homogeneity of the RGT (HOM) is the distribution or variance of the RGT value. The HOM therefore provides deeper insight into the homogeneity of relative germination and field emergence. Because most people refer to field emergence when they talk about the homogeneity of a seed lot, the HOM value can also be described as the overall homogeneity value of a seed lot for its relative performance in a field setting. In figure 4 one can see these different ASTEC values on a single seed oxygen metabolism curve
For further information, one can always request a Q_2 manual, 2009 by ASTEC Global (www.astec-global.com).

Materials and Methods

Four commercial tomato seed samples were bought in local seed stores. One sample was bought in Europe as a reference. All samples have been tested with the Q_2 (tomato protocol: TO-01) and all samples have been tested with classical ISTA methods. For the MGT counts were performed after 2, 3, 4, 5, 6, 7, 10 and 14 days.

The Mean Germination Time is a method that determines the time where 50% of the germinating seeds are germinated, while a T50 determines the time where 50% of all seeds are germinated. The MGT (Ranal and Santara, 2006) is calculated as the weighted mean of the germination time. The number of seeds germinated in intervals of time established for data collection is used as weight.

Results and Discussion

An overview of the obtained data can be found in table 1, the data encompasses two sets; the first one (Q_2 data) is data obtained through the Q_2 method described above, while the second part is data that has been obtained to classical methods.

If we look to the quality of the seeds obtained in Thailand and compare this to the seed quality from the European seed sample we see the following differences: Although some seed samples are close to the European sample for what concerns germination and even strong Q_2 stress, none of the Thai samples are coming close to the germination speed of the European sample (MGT of 5 d). There are major differences between the Thai seed samples. We do see significant differences in root emergence and germination as well in MGT. We do see similar differences in the obtained Q_2 data.

Table 1. results of Q_2 analyses of the quality of four tomato seed lots. And a comparison with traditional quality analyses by ISTA germination tests. Q_2 stress strong meaning the seeds that show a sigmoid type of oxygen consumption pattern) whereas Q_2 stress weak (meaning the seeds that show a linear or incomplete oxygen consumption pattern).. For explaination of the Astec values see the text in the introduction.

		Q_2 data							Lab data					
		Q_2 Stress			ASTEC values				Root emergence			ISTA germination		
		strong	weak	no	IMT	OMR	RGT	HOM	early	germ	MGT	early	germ	MGT
lot A	Thai comm	63%	29%	8%	48	2.2%	92	6.1	73%	92%	4.5	15%	88%	7.4
lot B	Thai comm	87%	12%	1%	43	2.5%	84	5.7	92%	99%	3.7	24%	97%	6.7
lot C	Thai comm	84%	16%	0%	33	2.2%	79	6.4	74%	88%	4.2	27%	76%	6.8
lot D	Thai comm	97%	3%	0%	35	2.9%	72	11.1	95%	98%	3.5	32%	96%	6.0
lot E	EU Comm	98%	2%	0%	35	3.2%	72	10.5	99%	100%	2.3	89%	97%	5.0

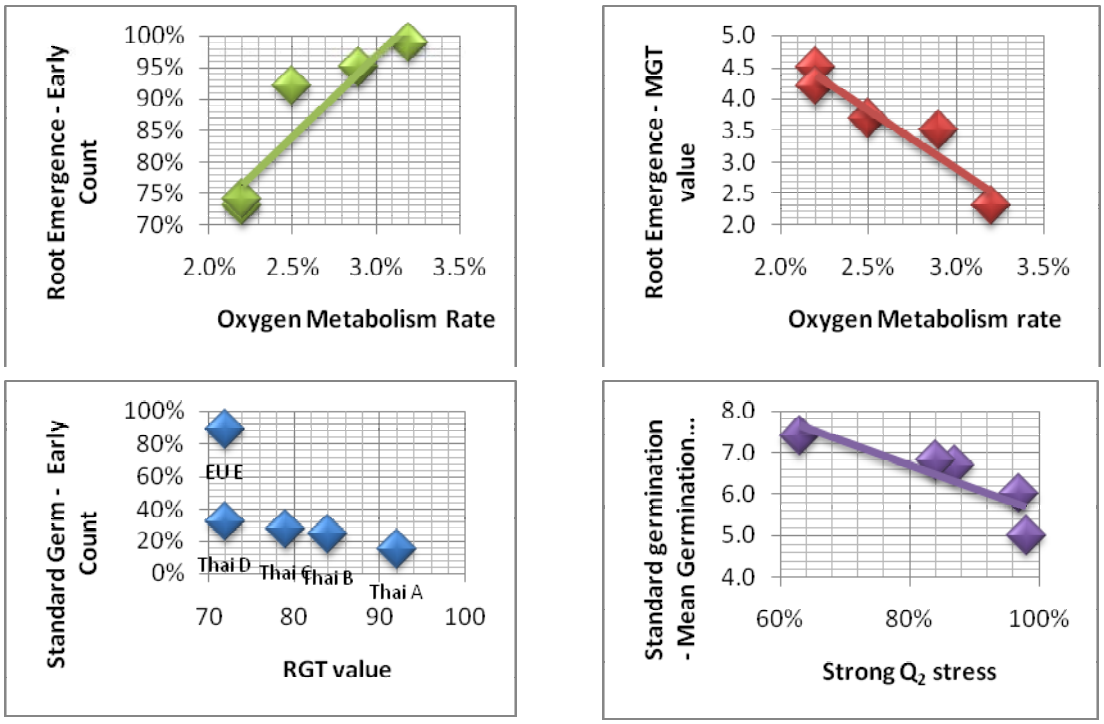

Figure 5 relation between classical ISTA seed quality parameters and those obtained in the Q_2 analyses.

In figure 5 one can see some correlations between a classical and the Q_2 parameters. For what concerns the data obtained through classical methods versus the Q_2 technology we can make the following comments; We see a good correlation between the Q_2 stress (strong) and the root emergence as well as an outstanding correlation between the OMR value (consumed oxygen per hour during germination) and the MGT (Mean Germination Time) values; both root emergence and standard ISTA test. The IMT (Increased metabolism) does not to seem correlated with germination nor MGT, but the RGT again correlates well with the emergence speed.

More information can be found in the report Single Seed Oxygen Measurement, 2009 prepared for the ISTA committee on advanced technologies (Van Asbrouck and Taridno 2009).

Conclusions

Seed quality testing is one of the most important items for a seed company; it will tell the managers how to adapt their production, processing and treatment schemes. At the same time it will make a difference between their and the competitors' seeds. New techniques in those seed labs are needed in order to follow the increasing need for quality and the shortening timeframes. The Q_2 technology can bring some solutions for those companies who want to understand better the behavior of their seeds, who need a better insight in the metabolic activities and who are working with reduced timelines.

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