

II. Scientific Report prepared by the Chair of the Management Committee of the Action, describing results achieved during the Action operation in this period, in no more than 3 pages (the report is "cumulative"). All items listed in Sections A, B, and C, below, must be addressed. Additional documentation such as extended scientific reports, proceedings of workshops, seminars or conferences may be provided separately as an annex to this report, and should be referenced in the report.

II.A. Innovative networking

- *Innovative knowledge resulting from COST networking through the Action. (Specific examples of Results vs. Objectives)*

(1) During the course of this period (2010-2011) it became very clear that the **epigenome is an essential factor controlling stress-regulated transcription**. Evidence was provided for heritable effects of stress on genome stability. This is reflected in several published contributions (see 2010-2011 publications in Annex I) such as *Alvarez M.E. et al. (2010). Molecular Plant Pathology 11: 563-576. Lang-Mladek C. et al. (2010) Molecular Plant 3: 594-602*. In the latter publication it was shown that temperature and UV-B stress cause immediate and heritable changes in the epigenetic control of a reporter gene in *Arabidopsis*. The authors show that stress led to a release of gene silencing which was correlated with pronounced alterations in histone occupancy and in histone H3 acetylation, but did not involve adjustments in DNA methylation. Transmission was reported of stress effects on reporter gene silencing to non-stressed progeny. Interestingly, this effect was restricted to areas consisting of a small number of cells and limited to a few non-stressed progeny generations. Stress-induced release of gene silencing was reset during seed aging. The fact that the release of gene silencing was transient points to the ability of plants to restrict stress-induced relaxation of epigenetic control mechanisms, which likely contributes to safeguarding genome integrity. The exact molecular nature of this phenomenon needs still to be revealed. **These discoveries are very important for designing strategies to obtain durable stress tolerance in plants.**

(2) So far unknown stress-related genes have been identified in a **deep transcriptome sequencing of the desiccation tolerant plant *Craterostigma plantagineum***: *Rodriguez M; Bartels D. et al. Mundy J. (2010) The Plant Journal 63: 212-228*. This transcript analysis confirms not only the known genes contributing to dehydration tolerance and regulating the transcripts accordingly, but also a number of unknown transcripts were discovered which are strongly up-regulated in response to dehydration. The functional identification of the genes will not be easy, as genetic approaches are limited, but **potentially some of the genes may represent interesting targets for engineering desiccation tolerance**. Further these genes are excellent for isolating promoters, which direct gene expression in stress-regulated and/or tissue specific manner.

(3) **Novel tools have been developed to allow studying larger genomic regions**. Agrobacterium-mediated transfer of large DNA into plants occurs at a low frequency. Bitrian et al. developed binary plant transformation vectors, which are suitable for gap-repair cloning of genes from BACs using recombineering methods previously developed for other organisms (*Bitrian M.; Roodbarkelari F.; Koncz C. (2011) Plant Journal 65: 829-842*). The authors show that recombineering facilitates PCR-based generation of precise translational fusions between coding sequences of reporter and plant proteins. Modified target genes alone or as part of a larger gene cluster can be transferred by high-frequency gap-repair into plant transformation vectors, stably maintained in Agrobacterium and transformed into plants. **This novel technology promises versatile application in experiments requiring the transfer of large DNA fragments.**

- *Significant scientific breakthroughs as part of the COST Action. (Specific examples)*

Emphasis has been on **elucidating further members of signalling pathways and on placing them in the regulatory network**. The construction of the regulatory network has considerably advanced during this reporting period. Progress concerning the regulatory network has been in several directions. One direction was to study interaction of different environmental factors; other studies were by extrapolating data and using them for modeling to present a network and by searching for targets and interaction partners of regulatory molecules. **Some of the significant**

scientific breakthroughs from this work have been published and will be briefly described:

(1) Examples for the interaction and mutual influence of different stress factors are the work by Wollenweber and Zilberstein (in collaboration with other Action COST members):

Wollenweber et al. (2011) observe **interaction of water deficits and/or a high-temperature** event during vegetative growth with either of these stress events applied during generative growth in wheat. Influence on the major grain proteins, which are the major nutrients of wheat, has been documented (Yang, F.; Wollenweber, B. et al. (2011) *Proteomics* 11, 1684-1695). **Amino acids are the building blocks of proteins including the grain proteins** and Ufaz et al. show that aspartate kinase activity is influenced by light and sucrose. Aspartate kinase is an enzyme in the biosynthesis for essential amino acids. Light or sucrose regulates aspartate kinase via a transcription factor of the bZIP family (Ufaz, S.; Galili, G.; Koncz, C.; Zilberstein, A. et al. (2011) *Planta* 233, 1025-1040).

(2) Modeling approaches: A mathematical model representing metabolite inter-conversions in the **central carbohydrate metabolism** of Arabidopsis was developed to simulate the diurnal dynamics of primary carbon metabolism in a photosynthetically active plant leaf (Nägele T.; Heyer A.G et al. (2010) *Plant Physiology* 153: 260-272). These modelling approaches are also nicely supported by experiments detailed in Angelovici R.; Fait A.; Fernie A.R.; Galili G. (2010) *New Phytologist* 89: 148-159. Here the authors show a **major negative effect of the seed-specific increased lysine synthesis and knockout of its catabolism** on the levels of a number of other metabolites. This metabolic alteration also influences the transcriptome, such as the onset of photosynthesis, as well as the turnover of specific transcriptional programs associated with seed embryonic traits. It is clear that such approaches will be in demand for understanding stress regulatory networks in the future. **Furthermore, studies like these are essential to identify limitations in breeding strategies for increased yield.**

(3) Complexity of networks and unravelling this complexity has nicely been demonstrated in the work published by Lumberras V.; Pages M. et al. (2010) *Plant Journal* 63: 1017-1030. Here it is described a novel Arabidopsis MAPK phosphatase, MKP5 that regulates ABA-signaling and lipid mobilization in seedling establishment.

(4) Work that was highlighted in the last progress report, such as identification of components of ABA receptors, was continued and discussed in detail at the INPAS meeting in Valencia. We expect that additional scientific breakthroughs will be discussed during the next Meeting (17-19 November 2011) to be held in Limassol (Cyprus).

- *Tangible medium term socio-economic impacts achieved or expected. (Specific examples)*

Several collaborations with industrial partners (example: Metapontum Agrobios from Italy; Bayer BioScience from Belgium; Vilmorin & Cie from France; Idem Biotechnology from Spain) have been established and **several patents** have been made by INPAS members (see also Monitoring Progress Reports). In addition, some of our meetings have been sponsored by Companies (i.e. Lemna Tec and Agrisera which are sponsors of our next meeting in Limassol). All of this ensures potential medium term socio-economic impacts.

- *Spin off of new EC RTD Framework Programme proposals/projects. (List)*

Several proposal EC applications have been made by INPAS participants during the course of the Action (see for example previous reports in Section III). It should be highlighted the preparation and lobbying in Brussels by INPAS members of a **Topic Proposal KBBE.2012.3.1-01: Improved water stress tolerance of crop plants. Call: FP7-KBBE-2012-6.** This is an excellent frame to which different INPAS members can apply for.

- *Spin off of new National Programme proposals/projects. (List)* For most partners, their participation in INPAS **has benefit their success in obtaining National grants.**

II.B. Inter-disciplinary networking

- *Additional knowledge obtained from working with other disciplines within the COST framework. (Specific examples)*

During the course of the COST project has become apparent that several groups started novel interactions on approaches towards understanding the network. It has been explained above that particularly interactions of scientists with a different experimental designs has been instrumental in the progress. Here we have seen **mathematical modelling, genetic screens, proteome analysis metabolite analysis in combination with plant physiology are essential for revealing the complexity and allowing novel designs for growing crop plants.**

Such type of interactions is reflected in several joint publications (see annexed list of publications), including those published in two special issues in Plant Signaling Behaviour and Plant Science (see below). We expect that work from additional interactions will be presented during the next scientific Meeting in Limassol.

- *Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide scientific impacts. (Specific examples)*

In this Action it has been demonstrated that the level of **inter-disciplinarity is sufficient to potentially provide scientific impacts** (see previous sections and reports).

- *Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide socio-economic impacts. (Specific examples)*

In this Action it is possible that the level of **inter-disciplinarity is sufficient to potentially provide socio-economic impacts** (see previous sections and reports). We expect that our collaboration with several Companies (see section II A) will provide a niche of further collaborations between academia and private companies.

II.C. New networking

- *Additional new members joining the Action during its life.*
47 new members from **21 new countries** (see MC composition at: http://w3.cost.esf.org/index.php?id=182&action_number=FA0605).
- *Total number of individual participants involved in the Action work. (Number of participants. Give % of female and of Early Stage Researcher participants).*
79 members (around 40% female). See website indicated above.
- *Involvement of Early Stage Researchers in the Action, in particular with respect to STSMs, networking activities, and Training Schools. In addition, justification should be provided if less than 4 STSMs were carried out during the year.*
From May 2010 to November 2011, **23 STSMs** were performed. Most of the grantees were **Early Stage Researchers** (see annexes II and III for STSM statistics). In addition, several grantees financed by our COST Action were attending or presenting their results in our INPAS Meetings.
- *Involvement of researchers from outside of COST Countries. (Number of participants from non-COST Countries approved by the CSO. Give % of such participants from countries with reciprocal agreements. Specify their contribution).*
11 Non-COST participants (2% from countries with reciprocal agreements: Australia and South Africa). Contributions: Most of them collaborate with COST participants. Some have been invited to annual workshops and to contribute in Special Journal issues in Plant Signalling and Behaviour and Plant Science.
- *Advancement and promotion of scientific knowledge through publications and other outreach activities. (Number of publications and other outreach activities that resulted from COST networking through the Action. Complete list should be given in an annex).*
For publications see Annex I. Other outreach activities include the **dissemination of INPAS**

in important scientific events like Gordon Conference on Salt & Water Stress In Plants From Molecules To Crops. (Les Diablerets, Switzerland June 2010) and Keystone Symposia on Plant Abiotic Stress Tolerance Mechanisms, Water and Global Agriculture (Keystone, Colorado, 17-22 of January 2011). Other dissemination events are included in attached previous reports.

- *Activities and projects with COST network colleagues.*
Joint research collaborations (reflected in STSMs), publications, participation in annual Management and Scientific Workshops, Steering Committee Meetings, joint projects and outreach activities (see previous sections and past reports)
- *The capacity of the Action members to raise research funds.*
The preparation and lobbying in Brussels by INPAS members of a **Topic Proposal KBBE.2012.3.1-01: Improved water stress tolerance of crop plants. Call: FP7-KBBE-2012-6** is an example of the capacity and potential of Action members to raise research funds (see also section IIA and previous reports).

II.D. Self evaluation

Indicate in no more than 1 page what, in the opinion of the MC, were the main successes, drawbacks (if any) and the key difficulties encountered (if any).

Main Successes:

1) The **worldwide interest in the Action and the success to attract new Partners**. The Action started with 32 participants from 19 countries. Currently, there are **79 members'** participants from 40 countries (31 COST; 9 non-COST)

(http://w3.cost.esf.org/index.php?id=181&action_number=FA0605)

2) We have been able to create a **close connection between the different 4 WGs involving interdisciplinary approaches** thus increasing scientific impacts. An example for this is the work on polyamines (PAs). As outlined by Alcazar, Tiburcio et al. (2010; 2011) PAs have regulatory functions and can be assigned new signaling molecules interacting with ABA, NO, ROS and inositol phospholipids in abiotic stress responses.

3) The gained **basic knowledge may provide socio-economic impacts**. For example, over-expression of specific genes involved in PA biosynthesis confers freezing tolerance not only in model plants (Arabidopsis and tobacco) (Tiburcio. Patent application; see previous reports), but also in valuable crops such as tomato (Collaboration Tiburcio from University of Barcelona with Iannacone from Metapontum Agrobios).

4) **The amount and excellence of the publications of INPAS members**. During 2010-2011 period, 166 papers have been published by INPAS: around 15 % resulting from the collaboration between members of the Action, and many of them are published in top journals (See Annex I)

5) **A special issue entitled Plant Abiotic Stress** containing articles and reviews of INPAS participants has recently been published **Stress in Plant Signalling & Behaviour** (Volume 6 Issue 2 February 2011), acting as Guest Editors: Narendra Tuteja, Antonio Fernandez Tiburcio, Ana Margarida Fortes and Dorothea Bartels (INPAS members). (See Annexes IV and V)

6) **A special issue** containing articles and reviews of INPAS participants is almost ready to be published in **Plant Science** (Vol. 182; Issue 1), acting as Guest Editors: AF. Tiburcio, B. Wollenweber, A. Zilberstein and C. Koncz (INPAS members). (See Annex VI)

7) **The success of INPAS dissemination in important scientific events** like Gordon Conference on Salt & Water Stress In Plants From Molecules To Crops. (Les Diablerets, Switzerland June 2010) and Keystone Symposia on Plant Abiotic Stress Tolerance Mechanisms, Water and Global Agriculture (Keystone, Colorado, 17-22 of January 2011). It is obvious that this strategic

dissemination plan has significantly contributed to increase the number of participants in the Action. See also annexed previous reports.

8) The **website** (<http://cost-inpas.org/>) has increased in interest. Since 2008, more than 18000 visitors (2/3 new visitors 1/3 returning visitors) visited the site and the statistics of the site tell us that they visit on average 3 pages of the site. The most popular pages are those of the management committee and the publication pages, followed by those of the scientific program. 70% of the visitors come from search engines, 15% from referring sites and 15% from direct visits. Most of the visitors come from the USA, India, Spain and Germany, followed by other EU countries (see Annex VII for statistics).

9) **The success of the third Science Workshop of INPAS** (organized by P. Carrasco in Valencia, Spain). Speakers from academia and Industry were invited in this meeting. The **4th INPAS Workshop** will be held in Limassol (Cyprus) next November. We expect a great success since the best scientists in this field have been invited as well as speakers from private companies (see <http://www.inpas2011.org/Inpas2011/Speakers.html>).

Difficulties:

During this year period, the chair has encountered some **difficulties** to get familiar with the e-cost system. However, it should be pointed out that most of the problems have been sorted out due to the constant support and collaboration of Dr. Ioanna Stavridou (Scientific Officer of the Action) and Mr. Peeters Christophe (Administrative Officer).

III. Previous scientific report(s)

Part II of past periods' reports are to be found here.

Individual past reports (2008; 2009) are annexed in separate documents.

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