HAYATI
Journal of Biosciences

HAYATI Journal of Biosciences

Country	Indonesia - SIR Ranking of Indonesia
Subject Area and Category	Agricultural and Biological Sciences Agricultural and Biological Sciences (miscellaneous) Biochemistry, Genetics and Molecular Biology Biochemistry, Genetics and Molecular Biology (miscellaneous)
Publisher	Institut Pertanian Bogor
Publication type	Journals
ISSN	20864094, 19783019
Coverage	2005-ongoing

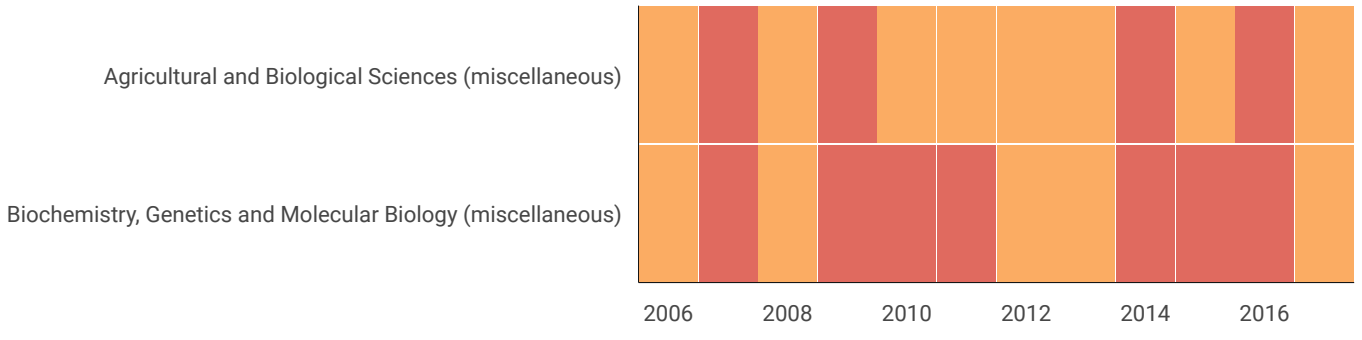
8

H Index

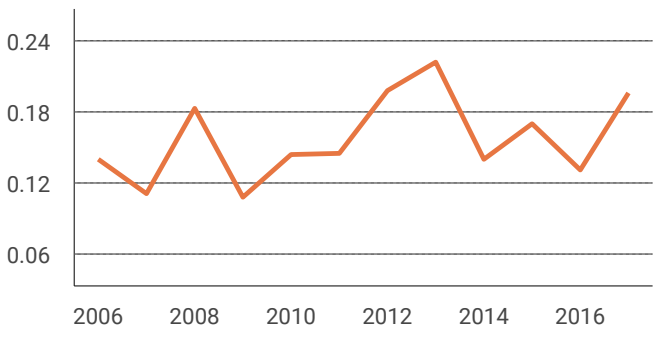
How to publish in this journal

Join the conversation about this journal

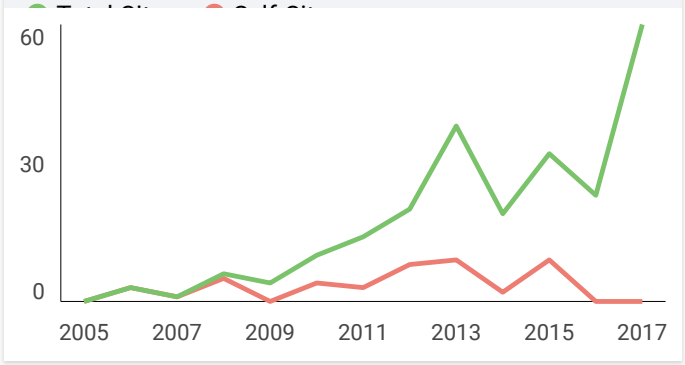
Quartiles

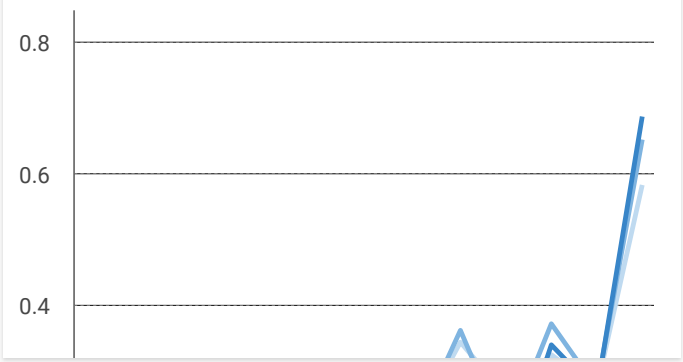


SJR

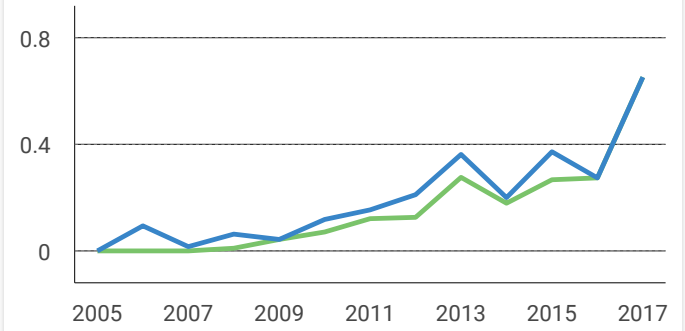


Citations per document

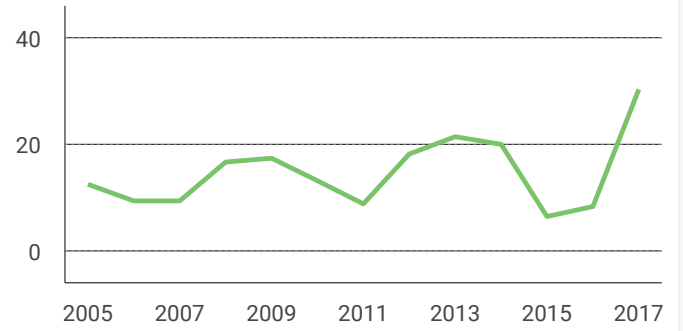




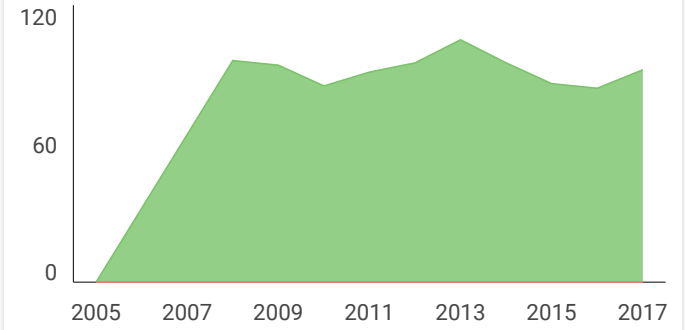
External Cites per Doc Cites per Doc



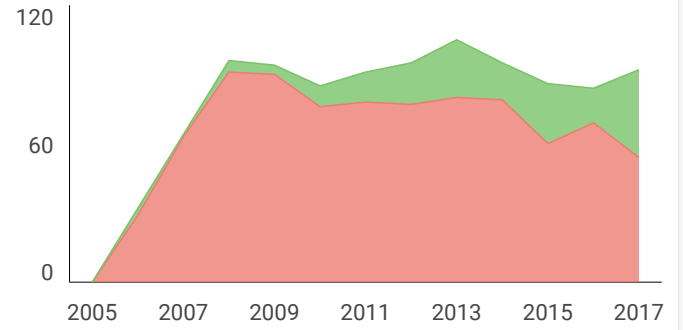
% International Collaboration

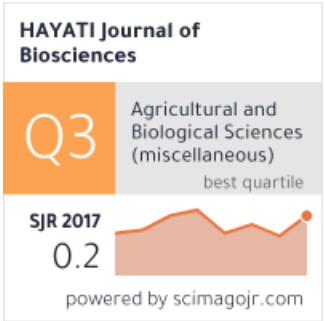


Citable documents Non-citable documents



Cited documents Uncited documents





← Show this widget in your own website

Just copy the code below and paste within your html code:

<a href="https://www.scimag

H **hasim** 6 months ago

good

reply

H **hasim** 6 months ago

congratulation for hayati team for ssuccessfully acchievement on q3 ranking.

reply

A **Ahmad Herison** 7 months ago

Dear Journal Management

please inform about submission in this journal and also the guide for author.
Thank you

reply

Elena Corera 7 months ago

Dear Ahmad, in the link below you will find the information corresponding to the author's instructions of this journal. Best regards, SCImago Team
https://www.elsevier.com/authors/journal-authors/submit-your-paper

Leave a comment

Name

Email
(will not be published)

I'm not a robot
reCAPTCHA
Privacy - Terms

Submit

The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.

HAYATI Journal of Biosciences
ISSN : 1978 - 3019

EDITORIAL TEAM

CHIEF EDITOR

Dr. Berry Juliandi, Bogor Agricultural University, Indonesia

MANAGING EDITOR

Dr. Ence Darmo Jaya Supena, Bogor Agricultural University, Indonesia

EDITORIAL BOARD

Prof. Colin Groves, Australian National University, Australia
Prof. Koji Nakamura, Kanazawa University, Japan
Prof. Yasumasa Bessho, Nara Institute of Science and Technology, Japan
Prof. Wei Zhang, Flinders University, Australia
Prof. Lisdar Idwan Sudirman, Bogor Agricultural University, Indonesia
Prof. Michel Raymond, Institut des Sciences de l'Evolution, France
Prof. Youji Nitta, Ibaraki University, Japan
Prof. Dave B. Nedwell, University of Essex, United Kingdom
Prof. Aris Tri Wahyudi, Bogor Agricultural University, Indonesia
Dr. Patrick O'Connor, The University of Adelaide, Australia
Dr . Ardiansyah, Universitas Bakrie, Indonesia
Dr. Mashuri Waite, University of Hawaii, USA
Dr. Atsushi Ido, Ehime University, Japan
Dr. Sastia Prama Putri, Osaka University, Japan
Dr. Bambang Retnoaji, Gadjah Mada University, Indonesia
Dr. Malcolm Wegener, The University of Queensland, Australia
Dr. M. Miftahudin, Bogor Agricultural University, Indonesia, Indonesia
Dr. Dodi Safari, Eijkman Institute, Indonesia
Dr. Emmanuel Paradis, Institut des Sciences de l'Evolution de Montpellier, France
Dr. Erin Phelps Riley, San Diego State University, USA
Dr. Sri Budiarti, Bogor Agricultural University, Indonesia
Dr. Rebecca Johnson, Columbia University, USA
Dr. Takuya Imamura, Kyushu University, Japan
Dr. Dyah Perwitasari, Bogor Agricultural University, Indonesia
Dr. Tsukasa Sanosaka, Keio University, Japan
Dr. Ocky Karna Radjasa, Diponegoro University, Indonesia
Dr. Tukirin Partomihardjo, Indonesian Research Center for Biology (LIPI), Indonesia
Dr. Yamato Tsuji, Kyoto University, Japan
D Darjono, Indonesian Research Center for Biology (LIPI), Indonesia

ISSN: 2086-4094

HAYATI Journal of Biosciences
ISSN : 1978 - 3019

JOURNAL CONTACT

MAILING ADDRESS

HAYATI Journal of Biosciences

Department of Biology

Faculty of Mathematics and Natural Sciences

Bogor Agricultural University

Darmaga Campus, Bogor 16680, Indonesia

Phone/Fax: +62-251-8421258;

E-mail: hayati_j_biosci@cbn.net.id

URL : http://journal.ipb.ac.id/index.php/hayati

PRINCIPAL CONTACT

Dr. Berry Juliandi
Editor in Chief
HAYATI Journal of Biosciences

Department of Biology

Faculty of Mathematics and Natural Sciences

Bogor Agricultural University

Darmaga Campus, Bogor 16680, Indonesia

Phone: +62-251-8421258
Fax: +62-251-8421258
Email: bjuliandi@ipb.ac.id

SUPPORT CONTACT

Suhendrik
Phone: +62-251-8421258
Email: hayati_j_biosci@cbn.net.id

ISSN: 2086-4094

HAYATI Journal of Biosciences
ISSN : 1978 - 3019

EDITORIAL POLICIES

FOCUS AND SCOPE

HAYATI Journal of Biosciences (HAYATI J Biosci) is an international peer-reviewed and open access journal that publishes significant and important research from all area of biosciences fields such as biodiversity, biosystematics, ecology, physiology, behavior, genetics and biotechnology. All life forms, ranging from microbes, fungi, plants, animals, and human, including virus, are covered by HAYATI J Biosci.

HAYATI J Biosci published by Department of Biology, Bogor Agricultural University, Indonesia and the Indonesian Society for Biology. We accept submission from all over the world. Our Editorial Board members are prominent and active international researchers in biosciences fields who ensure efficient, fair, and constructive peer-review process. All accepted articles will be published on payment of an article-processing charge, and will be freely available to all readers with worldwide visibility and coverage.

HAYATI J Biosci has been also indexed/registered in Crossref, DOAJ, CABI, EBSCO, Agricola and ProQuest. From October 2015, HAYATI is hosted by Elsevier and available free of charge through Science Direct.

SECTION POLICIES

ARTICLES

☑ Open Submissions ☑ Indexed ☑ Peer Reviewed

SHORT COMMUNICATION

☑ Open Submissions ☑ Indexed ☑ Peer Reviewed

PEER REVIEW PROCESS

HAYATI J Biosci implements Double-blind Peer Review Process. Editor in Chief will assign the manuscript to a corresponding section editor for further handling. The section editor will request at least two scientists to review the manuscript. Based on the comments from the revieweres, Section Editor, and Editor in Chief will make the decision on the manuscript.

PUBLICATION FREQUENCY

Starting Volume 22 (2015), HAYATI J Biosci published four times a year: January, April, July, and October.

OPEN ACCESS POLICY

This journal provides immediate open access to its content on the principle that making research freely available to the public supports a greater global exchange of knowledge.

ARCHIVING

This journal utilizes the LOCKSS system to create a distributed archiving system among participating libraries and permits those libraries to create permanent archives of the journal for purposes of preservation and restoration. More...

PUBLICATION ETHICS AND MALPRACTICE STATEMENT

A publication ethics and publication malpractice statement

(composed using the Publishing ethics resource kit and in compliance with Elsevier recommendations)

Ethical guidelines for journal publication (These guidelines are based on Elsevier policies)

HAYATI Journal of Biosciences publishes articles and short communications in biological fields such as biodiversity, biotechnology, and environmental issues. HAYATI covers wide range of all life forms topics including virus, microbes, fungi, plants, animals, and human.

HAYATI Journal of Biosciences is a peer-reviewed journal publishing articles to develop a coherent and respected network of biosciences knowledge. It is important to agree upon standards of expected ethical behaviour for all parties involved in the act of publishing: the author, the journal editor, the peer reviewer, the publisher and the society.

Department of Biology Bogor Agricultural University and The Indonesian Biological Society as publisher of HAYATI Journal of Biosciences takes its duties of guardianship all stages of publishing process and we recognize our ethical and other responsibilities.

We are committed to ensuring that advertising, reprint or other commercial revenue has no impact or influence on editorial decisions. In addition Department of Biology Bogor Agricultural University or The Indonesian Biological Society and Editorial Board will assist in communications with other journals and/or publishers where this is useful and necessary.

Duties of authors (These guidelines are based on Elsevier policies)

Reporting standards

Authors of reports of original research should present an accurate account of the work performed as well as an objective discussion of its significance. Underlying data should be represented accurately in the paper. A paper should contain sufficient detail and references to permit others to replicate the work. Fraudulent or knowingly inaccurate statements constitute unethical behavior and are unacceptable. Review and professional publication articles should also be accurate and objective, and editorial ëopinioní works should be clearly identified as such.

Data access and retention

Authors may be asked to provide the raw data in connection with a paper for editorial review, and should be prepared to provide public access to such data, if practicable, and should in any event be prepared to retain such data for a reasonable time after publication.

Originality and plagiarism

The authors should ensure that they have written entirely original works, and if the authors have used the work and/or words of others, that this has been appropriately cited or quoted. Plagiarism takes many forms, from ëpassing offî anotherís paper as the authorís own paper, to copying or paraphrasing substantial parts of anotherís paper (without attribution), to claiming results from research conducted by others. Plagiarism in all its forms constitutes unethical publishing behavior and is unacceptable.

Multiple, redundant or concurrent publication

An author should not in general publish manuscripts describing essentially the same research in more than one journal or primary publication. Submitting the same manuscript to more than one journal concurrently constitutes unethical publishing behavior and is unacceptable. In general, an author should not submit for consideration in another journal a previously published paper. Publication of some kinds of articles (e.g. clinical guidelines, translations) in more than one journal is sometimes justifiable, provided certain conditions are met. The authors and editors of the journals concerned must agree to the secondary publication, which must reflect the same data and interpretation of the primary document. The primary reference must be cited in the secondary publication.

Acknowledgement of sources

Proper acknowledgment of the work of others must always be given. Authors should cite publications that have been influential in determining the nature of the reported work. Information obtained privately, as in conversation, correspondence, or discussion with third parties, must not be used or reported without explicit, written permission from the source. Information obtained in the course of confidential services, such as refereeing manuscripts or grant applications, must not be used without the explicit written permission of the author of the work involved in these services.

Authorship of the paper

Authorship should be limited to those who have made a significant contribution to the conception, design, execution, or interpretation of the reported study. All those who have made significant contributions should be listed as co-authors. Where there are others who have participated in certain substantive aspects of the research project, they should be acknowledged or listed as contributors. The corresponding author should ensure that all appropriate co-authors and no inappropriate co-authors are included on the paper, and that all co-authors have seen and approved the final version of the paper and have agreed to its submission for publication.

Hazards and human or animal subjects

If the work involves chemicals, procedures or equipment that have any unusual hazards inherent in their use, the author must clearly identify these in the manuscript. If the work involves the use of animal or human subjects, the author should ensure that the manuscript contains a statement that all procedures were performed in compliance with relevant laws and institutional guidelines and that the appropriate institutional committee(s) has approved them. Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

Disclosure and conflicts of interest

All authors should disclose in their manuscript any financial or other substantive conflict of interest that might be construed to influence the results or interpretation of their manuscript. All sources of financial support for the project should be disclosed. Examples of potential conflicts of interest which should be disclosed include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Potential conflicts of interest should be disclosed at the earliest stage possible.

Fundamental errors in published works

When an author discovers a significant error or inaccuracy in his/her own published work, it is the authorís obligation to promptly notify the journal editor or publisher and cooperate with the editor to retract or correct the paper. If the editor or the publisher learns from a third party that a published work contains a significant error, it is the obligation of the author to promptly retract or correct the paper or provide evidence to the editor of the correctness of the original paper.

Duties of the Editorial Board (These guidelines are based on based on Elsevier policies and COPEís Best Practice Guidelines for Journal Editors)

Publication decisions

The editor of a peer-reviewed HAYATI Journal of Biosciences is responsible for deciding which of the articles submitted to the journal should be published. The validation of the work in question and its importance to researchers and readers must always drive such decisions. The editor may be guided by the policies of the journal's editorial board and constrained by such legal requirements as shall then be in force regarding libel, copyright infringement and plagiarism. The editor may confer with other editors or reviewers in making this decision.

Fair play

An editor should evaluate manuscripts for their intellectual content without regard to race, gender, sexual orientation, religious belief, ethnic origin, citizenship, or political philosophy of the authors.

Confidentiality

The editor and any editorial staff must not disclose any information about a submitted manuscript to anyone other than the corresponding author, reviewers, potential reviewers, other editorial advisers, and the publisher, as appropriate.

Disclosure and conflicts of interest

Unpublished materials disclosed in a submitted manuscript must not be used in an editor's own research without the express written consent of the author. Privileged information or ideas obtained through peer review must be kept confidential and not used for personal advantage. Editors should recuse themselves (i.e. should ask a co-editor, associate editor or other member of the editorial board instead to review and consider) from considering manuscripts in which they have conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies, or (possibly) institutions connected to the papers. Editors should require all contributors to disclose relevant competing interests and publish corrections if competing interests are revealed after publication. If needed, other appropriate action should be taken, such as the publication of a retraction or expression of concern.

Involvement and cooperation in investigations

An editor should take reasonably responsive measures when ethical complaints have been presented concerning a submitted manuscript or published paper, in conjunction with the publisher (or society). Such measures will generally include contacting the author of the manuscript or paper and giving due consideration of the respective complaint or claims made, but may also include further communications to the relevant institutions and research bodies, and if the complaint is upheld, the publication of a correction, retraction, expression of concern, or other note, as may be relevant. Every reported act of unethical publishing behavior must be looked into, even if it is discovered years after publication.

Duties of reviewers (These guidelines are based on based on Elsevier policies and COPEís Best Practice Guidelines for Journal Editors)

Contribution to editorial decisions

Peer review assists the editor in making editorial decisions and through the editorial communications with the author may also assist the author in improving the paper. Peer review is an essential component of formal scholarly communication, and lies at the heart of the scientific method.

Promptness

Any selected referee who feels unqualified to review the research reported in a manuscript or knows that its prompt review will be impossible should notify the editor and excuse himself from the review process.

Confidentiality

Any manuscripts received for review must be treated as confidential documents. They must not be shown to or discussed with others except as authorized by the editor.

Standards of objectivity

Reviews should be conducted objectively. Personal criticism of the author is inappropriate. Referees should express their views clearly with supporting arguments.

Acknowledgement of sources

Reviewers should identify relevant published work that has not been cited by the authors. Any statement that an observation, derivation, or argument had been previously reported should be accompanied by the relevant citation. A reviewer should also call to the editor's attention any substantial similarity or overlap between the manuscript under consideration and any other published paper of which they have personal knowledge.

Disclosure and conflict of interest

Unpublished materials disclosed in a submitted manuscript must not be used in a reviewerís own research without the express written consent of the author. Privileged information or ideas obtained through peer review must be kept confidential and not used for personal advantage. Reviewers should not consider manuscripts in which they have conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies, or institutions connected to the papers.

Editor in Chief

GUIDELINES FOR FILING A COMPETING INTEREST STATEMENT

Definition:

Conflict of interest (COI) exists when there is a divergence between an individual's private interests (competing interests) and his or her responsibilities to scientific and publishing activities such that a reasonable observer might wonder if the individual's behavior or judgment was motivated by considerations of his or her competing interests. COI in medical publishing affects everyone with a stake in research integrity including journals, research/academic institutions, funding agencies, the popular media, and the public.COI may exist in numerous forms including financial ties, academic commitments, personal relationships, political or religious beliefs, and institutional affiliations. All authors should declare their COI, if any, during the manuscript submission. Reviewers are asked to declare their COI after they accept to review a manuscript. Editors should also declare their COI during handling of a manuscript.

Managing COI depends on disclosure because it is not possible to routinely monitor or investigate whether competing interests are present. COI disclosed by authors will be presented in the Editorial Board and an appropriate action will be taken. Those reviewers and Editors with COI will be excluded from the manuscript process. If competing interests surface from other sources after a manuscript is submitted or published, *HAYATI Journal of Biosciences* investigates allegations of COI and depending on their nature, appropriate actions will be taken if the allegations were found to be true. If a manuscript has been published and COI surfaces later, the journal will publish the results of the investigation as a correction to the article and ask the author to explain, in a published letter, why the COI was not revealed earlier.

ISSN: 2086-4094

HAYATI
ISSN : 1978 - 3019
Journal of Biosciences

VOL 16, NO 1 (2009)

MARCH 2009

TABLE OF CONTENTS

ARTICLES

ISSN: 2086-4094

HAYATI
ISSN : 1978 - 3019
Journal of Biosciences

PROLINE AND ABSCISIC ACID CONTENT IN DROUGHTED CORN PLANT INOCULATED WITH AZOSPIRILLUM SP. AND ARBUSCULAR MYCORRHIZAE FUNGI

NOVRI YOULA KANDOWANGKO, GIAT SURYATMANA, NENNY NURLAENY, ROBERT DJONGGI MARULI SIMANUNGKALIT

ABSTRACT

Plants that undergo drought stress perform a physiological response such as accumulation of proline in the leaves and increased content abscisic acid. A research was conducted to study proline and abscisic acid (ABA) content on drought-stressed corn plant with Azospirillum sp. and arbuscular mycorrhizae fungi (AMF) inoculated at inceptisol soil from Bogor, West Java. The experiments were carried out in a green house from June up to September 2003, using a factorial randomized block design. In pot experiments, two factors were assigned, i.e. inoculation with Azospirillum (0, 0.50, 1.00, 1.50 ml/pot) and inoculation with AMF Glomus manihotis (0, 12.50, 25.00, 37.50 g/pot). The plants were observed during tasseling up to seed filling periods. Results of experiments showed that the interaction between Azospirillum sp. and AMF was synergistically increased proline, however it decreased ABA.

Key words: Azospirillum sp., Arbuscular Mycorrhizae fungi, Corn, drought, proline, abscisic acid (ABA)

FULL TEXT:

PDF

DOI: http://dx.doi.org/10.4308/hjb.16.1.%25x

ARTICLE METRICS

No metrics found.

Metrics powered by PLOS ALM

REFBACKS

- There are currently no refbacks.

ABOUT THE AUTHORS

NOVRI YOULA KANDOWANGKO

Indonesia

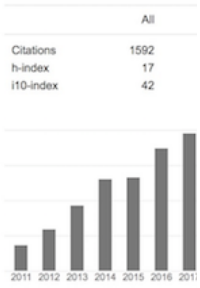
GIAT SURYATMANA

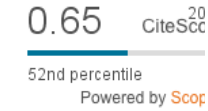
NENNY NURLAENY

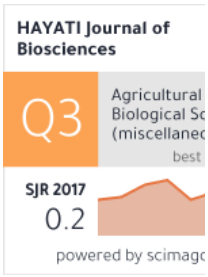
ROBERT DJONGGI MARULI SIMANUNGKALIT

OPEN JOURNAL SYSTEMS

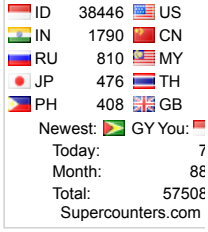
HAYATI J Biosci Citations







Visitor Statistics since 3 Oct 2015



JOURNAL CONTENT

Search

Search Scope

All

Search

Browse

USER

Username

Password

Remember me

Login

Department of BIOLOGY

FAKULTAS MIPA IPB

HAYATI Journal of Biosciences, March 2009, p 15-20 Vol. 16, No. 1
ISSN: 1978-3019

Proline and Abscisic Acid Content in Droughted Corn Plant Inoculated with *Azospirillum* sp. and Arbuscular Mycorrhizae Fungi

NOVRI YOULA KANDOWANGKO[1*], GIAT SURYATMANA[2], NENNY NURLAENY[2], ROBERT DJONGGI MARULI SIMANUNGKALIT[3]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Gorontalo State University, Jalan Jenderal Soedirman 6, Gorontalo 96128, Indonesia

[2]Department of Agrotechnology, Faculty of Agriculture, Padjadjaran University, Jalan Raya Jatinangor Km. 7, Sumedang 40000, Indonesia

[3]Soil Research Center, Jalan Tentara Pelajar 3A, Bogor 16111, Indonesia

Received April 7, 2008/Accepted February 10, 2009

Plants that undergo drought stress perform a physiological response such as accumulation of proline in the leaves and increased content abscisic acid. A research was conducted to study proline and abscisic acid (ABA) content on drought-stressed corn plant with *Azospirillum* sp. and arbuscular mycorrhizae fungi (AMF) inoculated at inceptisol soil from Bogor, West Java. The experiments were carried out in a green house from June up to September 2003, using a factorial randomized block design. In pot experiments, two factors were assigned, i.e. inoculation with Azospirillum (0, 0.50, 1.00, 1.50 ml/pot) and inoculation with AMF *Glomus manihotis* (0, 12.50, 25.00, 37.50 g/pot). The plants were observed during tasseling up to seed filling periods. Results of experiments showed that the interaction between *Azospirillum* sp. and AMF was synergistically increased proline, however it decreased ABA.

Key words: *Azospirillum* sp., Arbuscular Mycorrhizae fungi, Corn, drought, proline, abscisic acid (ABA)

INTRODUCTION

Under field conditions, plant generally undergoes water deficit due to water limitation in the plant roots area which resulted in lower water absorption. Transpiration rate that precedes water absorption by root will subsequently decrease the plant water content (Kramer 1983). Consequently, it will reduce plant turgor pressure and water potential. These conditions might disturb biochemical and physiological processes, hence resulted in anatomical or morphological changes of the plant.

Plants that undergo drought stress perform a physiological response such as accumulation of proline in the leaves. Proline accumulation usually more pronounce than other amino acids in the under drought condition plant. During the beginning of drought stress, proline content increase slowly, however it increase dramatically after the severe drought (Girousse *et al*. 1996; Yang & Kao 1999). Yoshiba *et al*. (1997) reported that the accumulation of proline was higher in the tolerant than in the sensitive plant. This implied that proline was able to support plant to recover after water stress and during rewatering (Peng *et al.* 1996).

Clawson *et al*. (1989) reported that under drought stress the plant usually enhance abscisic acid content (ABA) content in their leaves as well. ABA synthesis was started immediately after the plant was exposed to the dry media. This process reduces stomatal pores and finally the pores were close. After rewatering, the ABA concentration in the guard cell of the stomata reduces. This process subsequently increases the concentration of K^+ ion and turgor pressure results in the opening of stomata; hence, it increase photosynthesis process due to improvement of CO_2 supply. In many cases, plants that undergoes water deficit damage its cortex tissues and root. However, this will not be the case if the plant has a symbiosis relation with arbuscular mycorrhiza fungus (AMF). This is due to soil volume surrounding the plant can be explored by the root with AMF was approximately 12-15 cm^3 of soil (6-15 folded), while 1-2 cm^3 without AMF (Sieverding 1991). This means, symbiosis between plant and AMF will perform adaptable to water deficit.

The root of the plant with mycorryza can grow normally soon after drought period. This is due to AMF hypha is still able extract water in the microphores of water table in the soil, while the plant root can't. A wide spread of AMF hypha surrounding the root can help the plant to absorb more water (Osonubi *et al.* 1991). Another positive effect of AMF on the plant is its ability to improve phosphorus availability for the host plant (Sieverding 1991).

Another microorganism that has a role in plant growth promotion is *Azospirillum* that colonized in the intracellular of cortex and endodermis cells of the roots and *Azospirillum* can survive under the drought conditions (Michiels *et al.* 1989). *Azospirillum* sp. is able to improve absorption of N, P, K, and micronutrient, plant water status, plant dry weight, and yield of corn as well (Cosico *et al.* 1991).

Recently, there is lack of data for the role of AMF and *Azospirillum* to support physiological processes during the drought stress. This encouraged our group to investigate the

*Corresponding author. Phone: +62-435-821125,
Fax: +62-435-821752, E-mail: novri.kandowangko@ung.ac.id

role of AMF and *Azospirillum* in relation to proline and ABA accumulation in corn during the drought stress especially between the stage of flowering and seed filling.

MATERIALS AND METHODS

Inceptisol soil used for these experiments was characterized with silty loam texture and low fertility status. This soil was collected compositely from Cimanggu, Bogor, West Java, at 0-25 cm below the soil surface. No sterilization was carried out to this soil. The physical properties of the soil were: moisture content at field capacity with pF = 2.54 was 36.76% and at permanent wiling point with pF = 4.20 was 4.13%. Other physical properties of the soil were available water content, dry air water content, and soil dry weight at room condition were 32.63%, 11.71%, and 10,000 g, respectively.

To determine the stress conditions with 30% of available water content, we used the formula as follow:

Water content = (30% x available water content) + soil water content at permanent wiling point

This formula was important to determine soil weight for every polybag that will be used for drought treatments.

Wet weight of soil for every polybag was calculated by:

$$\text{Water content} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}}$$

Based on the initial biological study using most probable number method (MNP), we found that the population of *Azospirillum* sp. was 3.30 x 10^6 cells per 100 g of soil, while infective propagule of AMF (spores, roots colonized by AMF and AMF hypha) was 6.069 propagules per 100 g of soil.

In this experiment we used Bayu variety corn seeds having 97% germination rate. The AMF inoculum that was used in the experiment was *Glomus manihotis* in the form of infective propagules. Liquid inoculums of *Azospirillum* sp. (Isolate number of Az.7) was given in the density of 10^8 of cell/ml. The plant materials, AMF inoculums and isolate of *Azospirillum* sp. were acquired from Center of Crop Biotechnology and Genetic Resources (BB Biogen), Bogor.

The experiments were carried out in glasshouse using Blok Randomize Design with two factors, i.e. (i) dosage of *Azospirillum* sp. notified by "A" with four levels of treatment (0, 0.5, 1.0, and 1.5 ml of *Azospirillum* sp. with concentration of 10^8 cells/ml for every polybag; and (ii) the dosage of AMF notified by "M" which also contained four levels of treatment (0, 12.5, 25.0, and 37.5 g of AMF per polybag). All treatments comprised of 16 combinations with 2 replications for every treatment. To obtain some correction factors of plant fresh weight, 16 polybags without plant were also added in the experiment.

Method. Ten kg of dry-air soil was sieved with 2 mm of soil siever and was loaded to the polybag. To facilitate watering, on every polybag, a pair of plastic tubes (0.5 inch of diameter) was installed in two different deep levels, i.e. 10 and 15 cm at different side of the polybag. We expected that water would spread evenly by using those two levels of tubes.

To support plant growth, the plant was fertilized using basic fertilizers one day prior planting. The basic fertilizers for every polybag were 0.7, 0.5, and 1.0 g of Urea, SP-36, and KCl, respectively. These three fertilizers were mixed with the soil prior to media loading in the polybag and were arranged in the glasshouse.

Before planting, corn seeds were sterilized using 0.1% of $HgCl_2$ (10 minutes) and washed using sterile water (5 times). The inoculation of *Azospirillum* sp. was carried out by spraying the inoculums to the soil around the seedbed with the dosage that has been explained before, while for AMF, the inoculums were given as infective propagule by spreading them under the seed during seed planting. Three seeds were planting for every polybag in 5 cm depth.

After a week, two homogenous seedlings were chosen out of three seedlings. Within 44 days after planting (before flowering), the plants were grown under normal conditions with water content was maintained nearly constant to about 100% of field capacity (FC). Subsequently in 45-55 days at flowering and seed filling stage, drought stress was given by watering 30% of water availability to all plants. Water content of media was controlled by gravimetric method to determine additional water. The increased plant weight for correction factor was calculated between 14 up to 49 days plant. As comparison to this method, the "Bouyoucos moisture meter" was also used. After 55 days, i.e. after seed filling stage, the plants were harvested.

In this experiment, proline and ABA content of the plant were measured at the fully expanded leaves of the 55 days plant by using the 4th leaf from the tip of the plant. Proline was analyzed based on Bates *et al*. (1973) method by using pure proline as the standard. Acid ninhydrine was prepared by preheating 1.2% of ninhydrine into a mix of 30 ml of glacial acetic acid and 20 ml of 6 M phosphoric acid. The mixture was then stored at 4 ^oC, which was stable within 24 hours. Proline of approximately 0.5 g of fresh leaves was extracted with 10 ml 3% sulfosalicilic acid, then was filtrated using 2 sheets of Whatman paper no 42. About 2 ml of filtrate was reacted with 2 ml of acid ninhydrine and 2 ml of glacial acetic acid in test tube for 1 hour at 100 ^oC and the reaction was abolished in icebath. The mixture was extracted using 4 ml toluene and was shake using test tube stirrer for 15-20 second. Chromophore in the solution was warmed at room temperature and the absorbance was measured with spectrophotometer at ë = 520 nm. For this measurement, toluene was used for the blank sample. Proline content (ì mol/g) was determined by using standard curve and calculated based on the fresh weight sample (Bates *et al*. 1973) as follow:

$$\text{ìmol prolin/g fresh weight} = \frac{[(\text{ìg proline/ml x ml toluene})/115.5\ \text{ìg/ìmol}]}{(\text{g sample})/5}$$

ABA content was measured using Elisa Kits method and determined by using HPLC model 510.

AMF Colonization in the Root. AMF colonization in the root was analyzed using fuchsin acid staining method and colonized roots were calculated using slide length method (Gerdemann 1975): (the number of infected roots/total number of observed root) x 100%

Nitrogen fixation was determined from the fresh root sample by using acetylene reduction activity (ARA) method and was analyzed with gas chromatography. ARA quantification was as follow:

$$\text{ARA (î mol g}^{-1}\text{jam}^{-1}) = \frac{X}{\text{Ethylene molecule weight (EMW) x time of incubation (t) x fresh root weight (FRW) x Standard}}$$

Data Analysis. The effects of each treatment and their interaction on response variables were analyzed by using univariate analysis. Advance analysis was carried out to understand specific response of the treatments using DMRT test at 5% level.

RESULTS

Proline. The interaction of *Azospirillum* and AMF was significantly influenced proline content of corn plant subjected to drought stress (Table 1). Single effect of *Azospirillum* inoculation was able to improve proline content of leaf although under lower dosage treatment (0.50 ml/polybag) as compared to control (without inoculation) plant. The same response occurred at the AMF treatment with dosage of 12.50 g/polybag. On the other hand, if higher dosage of *Azospirillum* was applied, no significantly different showed in the proline content (P = 0.05). In addition, the application of AMF with higher dosage caused the decrease of proline content.

The different combination of *Azospirillum* and AMF gave different effect on proline content and the different dosage of *Azospirillum* and AMF showed inconsistent effect on proline content. The effects tended to be antagonist between *Azospirillum* and AMF. This can be seen from the data about the interaction effect of *Azospirillum* (0.50 ml/polybag) with AMF (12.50 and 25.00 g/polybag) which was not significantly different (P = 0.05) from the plant without inoculation. However, if the AMF dosage was improved (37.50 g/polybag) the proline content even decreased. In the same way, if a lower dosage of AMF combined with medium (1.00 ml/polybag) and high dosage (1.50 ml/polybag) of *Azospirillum* was also not significantly different (P = 0.05) from control, and if the dosage was improved further it also caused the decrease of proline content.

Abscisic Acid (ABA). The ANOVA data indicated that inoculation of *Azospirillum* and AMF significantly (P = 0.05) influenced ABA content of corn leaf that was subjected to drought stress during flowering and seed filling (Table 1). ABA is a hormone that has a special role as chemical signal to the plant organs that undergoes physiological drought stresses. Without inoculation of either *Azospirillum* or AMF, the plant subjected to drought stress had maximum ABA content 455 ñmol/g of fresh weight as compared to other treatments. With a single treatment, the inoculation using various dosage of *Azospirillum* decreased ABA content more than that of using AMF with low and medium dosage (12.50 and 25.00 g/polybag AMF respectively). The combination of *Azospirillum* and AMF also decreased of ABA content as compared to control plant. Meanwhile, the increase of *Azospirillum* or AMF dosage did not affect the ABA content.

DISCUSSION

The inoculation of *Azospirillum* sp. with a particular dosage was able to improve proline content of corn subjected to drought stress during the flowering and seed filling. This phenomenon may be associated with the role of *Azospirillum* which is able to fix nitrogen compound from the air (Table 1), and consequently influenced the accumulation of proline content. This process might be able to support the plant to be more adaptable to severe drought stress when water availability was only about 30%. The increase of proline content was might associated with the development of AMF hypha which assisted the plant to extract water as well as nutrients from the dry soil. This data was in accordance to that of Ruiz-Lozano *et al.* (1995). They found that proline content was

Table 1. Response of *Azospirillum* dan FMA *G. Manihotis* innoculation on root colonization by FMA, nirogen uptake, proline and ABA content of maize under drought conditions during flowering and pod filling

Azospirillum (ml/polybag)	FMA (g/polybag)	Root colonization (%)	Fixation N (ηmol/g fresh root/h)	Proline content (ηmol/g fresh weight)	ABA content (ρmol/g fresh weight)
0	0	11a	7a	95a	455c
	12.50	64b	15b	115b	265b
	25.00	62b	14b	90a	250b
	37.50	64b	13b	105ab	155a
0.50	0	13a	12b	120b	125a
	12.50	63b	17bc	115b	125a
	25.00	74b	16bc	115b	120a
	37.50	65b	14b	95a	100a
1.00	0	25a	19c	115ab	90a
	12.50	44ab	16bc	130b	85a
	25.00	46b	16bc	105a	85a
	37.50	76c	19c	105a	75a
1.50	0	18a	16bc	125b	75a
	12.50	29a	19c	110ab	75a
	25.00	47b	19c	100a	65a
	37.50	76c	21d	125b	60a

higher (119.60 nmol/g fresh weight) in drougted salad that had been inoculated by *Glomus deserticola*, while it was only 16.20 nmol/g in the drougted salad without inoculation.

According to Fidelibus *et al*. (2001) the effect of AMF on adaptability of host plant to drought stress is probably a secondary effect due to the increase of nutrient status of the host plants. Subramanian and Charest (1999) reported that AMF colonization on corn plant was able to stimulate the activation of principle enzymes that involve in nitrogen assimilation such as *nitrate reductase* and *glutamate synthetase* especially during drought conditions. The improvement of this enzyme activity can change and increase nitrogen content of the plant which resulted in increase of proline content. Consequently, this situation can improve plant adaptability to drought stress and plant recovery soon after rewatering.

On the contrary, the plants without inoculation of *Azospirillum* and AMF showed severe stress due to drought (Figure 1) indicated by wilting and rolling leaves. These plants also had a higher ABA content in their leaves. The increase of ABA content in the plant in response to drought stress has been reported many authors such as Alves and Setter (2000).

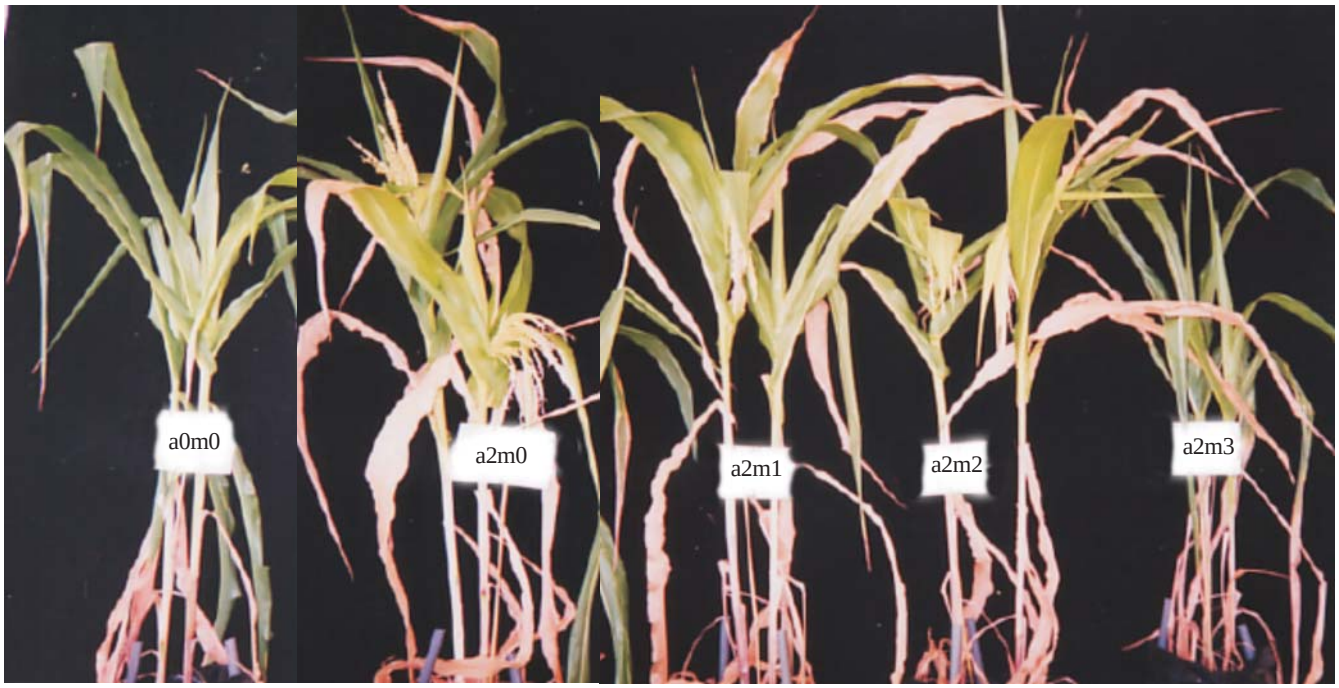


Figure 1. Maize plants that were grown under drought stress in the glasshouse using polybag with different treatments of *Azospirillum* sp. (a0: control, a2: 1 ml of 10^8 cell/ml) and arbuscular mycorrhizae (m0: control, ml : 12 g of mycorrhizae, m2: 25 g of mycorrhizae, m3: 37.5 g of mycorrhizae).

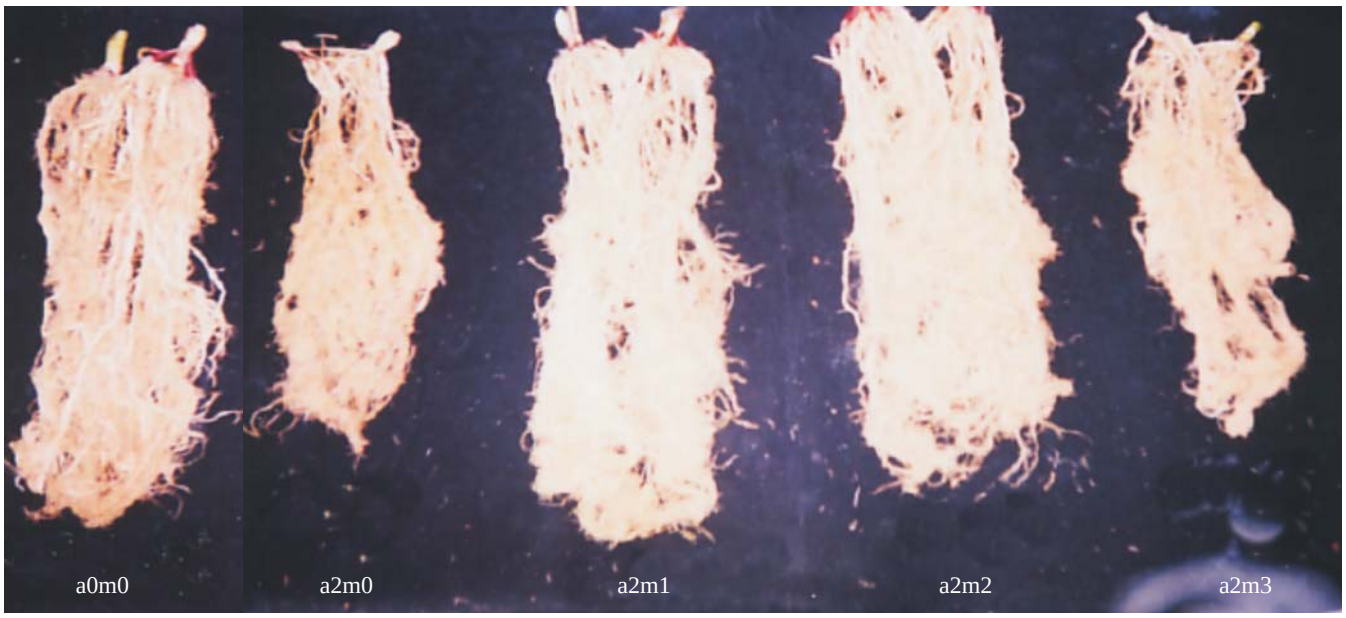


Figure 2. The root of maize that were grown under drought stress with different treatments of *Azospirillum* sp. (a0: control a2: 1 ml of 10^8 cell/ml) and arbuscular mycorrhizae (m0: control, ml : 12 g of mycorrhizae, m2: 25 g of mycorrhizae, m3: 37.5 g of mycorrhizae).

According to Mansfield and McAinsh (1995), the plant under drought stress generally increase its ABA content more than 20 times e.g. up to 8 femtogram per cell (80^{-15} g/cell). During the drought stress, roots synthesize ABA and it transports through plant xylem to the leaves which subsequently resulted in stomatal closure. ABA induces stomatal closure through an inhibition of proton pump activity that depend on ATP abundance in plasma membrane of guard cells. ABA works on the surface of intercellular of cell membrane prevent the inclusion of K^+ to the guard cell. Hence, K^+ and consequently water exclude from the guard cells which cause the reduction of turgor pressure and finally stomatal closure. Ordinarily, proton pump excludes the proton from the guard cells where at the same time the K^+ is accumulated to the guard cells. This process reduced the osmotic pressure in the guard cells which induces absorption of water and finally stomatal opening. Another experiment has also indicated that plasma membrane reduced turgor pressure by accelerated Ca^{2+} transporting into the cell. Ca^{2+} and phosphoinositol have a role to activate genes that are required to synthesize ABA (Salisbury & Ross 1995).

The inoculation of *Azospirillum* sp. with a certain dosage to corn plant subjected to drought stress during flowering and seed filling was able to reduce ABA content in the plants. This probably was associated with the function of *Azospirillum* sp. in nitrogen fixation (Table 1) which influenced nitrogen content in the soil and plant. Orcutt and Nilsen (2000) reported that ABA concentration inside the plants might be influence by the level of nitrogen source (NO_3^- or NH_4^+). In addition, various contents of Zn, K, and P inside the plant were also influenced ABA concentration in the plants.

The reduction of ABA content in droughted plant inoculated by AMF may be in associated to the development of AMF hypha which assists plant to extract water and essential nutrients under dry conditions. Similar result has also been reported by Duan *et al.* (1996), Ebel *et al.* (1997), and Goicoechea *et al.* (1997) who found that application of AMF was able to reduce ABA content of droughted plant. This results suggested that inoculation of AMF to the drougted plant is able to alleviate the strained by manipulation of stomatal conductance so that the stomata are still remained open for the longer period.

This experiment indicated as well that the inoculums of *Azospirillum* sp. and AMF can work synergically and was able to improve proline content and reduce ABA concentration in the corn plant subjected to drought stress during flowering and seed filling. Trotel-Aziz *et al.* (2003) reported that there is good correlation of proline accumulation and ABA concentration changes. The phytohormone ABA may work at the beginning site of enzyme activity of Ä[1]-*pyrroline-5-carboxylate synthetase* (P5CS), as the response to induce substrate during proline synthesis or at the end of enzymes activity of P5CS which associated to the level of *proline dehydrogenase* (PDH).

ACKNOWLEDGEMENT

We thank to Head office of The Center of Crop Biotechnology and Genetic Resources (BB Biogen), Bogor, due to his permission on using laboratory and glasshouse facilities.

REFERENCES

Alves AAC, Setter TL. 2000. Response of cassava to water deficit: leaf area growth and abscisic acid. *Crop Sci* 40:131-137.

Bates LS, Waldren RP, Teare ID. 1973. Rapid determination of free proline for water-stress studies. *Plant Soil* 39:205-207.

Clawson KL, Jackson RD, Pinter PJ. 1989. Evaluating plant water stress with canopy temperature differences. *Agron J* 81:858-863.

Cosico WC, Garcia MU, Alog RA, Santos TSJ. 1991. *Azospirillum* inoculation and corn growth. Organic Recycling in Asia and the Pacific. *Rapa Bulletin* 7:8.

Duan X *et al*. 1996. Mycorrhizal influence on hydraulic and hormonal factors implicated in the control of stomatal conductance during drought. *J Exp Bot* 47:1541-1550.

Ebel RC, Duan X, Still DW, Augé RM. 1997. Xylem sap abscisic acid concentration and stomatal conductance of mycorrhizae *Vigna unguiculata* in drying soil. *New Phytol* 135:755-761.

Fidelibus MW, Martin CA, Stutz JC. 2001. Geographic isolates of *Glomus* increase root growth and whole-plant transpiration of citrus seedling grown with high phosphorus. *Mycorrhiza* 10:231-236.

Gerdemann JW. 1975. Vesicular-arbuscular mycorrhizae. In: Torrey JG, Clarkson DT (eds). *Development and Function of Roots*. London: Academic Pr. p 575-591.

Girousse C, Bournoville R, Bonnemain JL. 1996. Water deficit induced changes in concentration in proline and some other amino acids in phloem sap of Alfalfa. *Plant Physiol* 111:109-113.

Goicoechea N, Antolin MC, Sánchez-Díaz M. 1997. Influence of arbuscular mycorrhizae and *Rhizobium* on nutrient content and water relation in drought – stressed alfalfa. *Plant Soil* 192:261-268.

Kramer PJ. 1983. *Water Relations on Plants*. San Diego: Acad Pr.

Mansfield TA, McAinsh MR. 1995. Hormones as regulators of water balance. In: Davies PJ (ed). *Plant Hormones. Physiology, Biochemistry and Molecular Biology*. 2nd ed. Dordrecht: Kluwer Acad Publ. p 598-616.

Michiels K, Vanderleyden J, Van Gool A. 1989. *Azospirillum* – plant roots association. *Rev Biol Fertil Soils* 8:356-368.

Orcutt DM, Nilsen ET. 2000. *The Physiology of Plants Under Stress. Soil and Biotic Factors*. New York: John Wiley & Sons.

Osonubi OK, Mulongoy K, Owotoyo OO, Atayese MO, Okali DUU. 1991. Effects of ectomycorrhizal and VAM fungi and drought tolerance of four leguminous woody seedlings. *Plant Soil* 136:131-143.

Peng Z, Lu Q, Verma DPS. 1996. Reciprocal regulation of Delta(1)-pyrroline-5-carboxylate synthetase and proline dehydrogenase genes controls proline levels during and after osmotic stress in plants. *Mol Gen Genet* 253:334-341.

Ruiz-Lozano JM, Azcon R, Gomez M. 1995. Effects of arbuscular-mycorrhizal *Glomus* species on drought tolerance: physiological and nutritional plant responses. *Appl Environ Microbiol* 61:456-460.

Salisbury FB, Ross CW. 1995. Plant Physiology. 4 th ed. *Terjemahan* Diah R. Lukman dan Sumaryono. ITB, Bandung.

Sieverding E. 1991. *Vesicular – Arbuscular Mycorrhiza Management in Tropical Agrosystem*. Eachborn: GTZ.

Subramanian KS, Charest C. 1999. Acquisition of N by external hyphae of arbuscular mycorrhizal fungus and its impact on physiological responses in maize under drought-stressed and well watered conditions. *Mycorrhiza* 9:69-75.

Trotel-Aziz P, Niogret MF, Deleu C, Bouchereau A, Aziz A, Larher FR. 2003. The control of proline consumption by abscisic acid during osmotic stress recovery of canola leaf discs. *Physiol Plant* 117:213-221.

Yang CW, Kao CH. 1999. Importance of ornithine-ä-aminotransferase to proline accumulation caused by water stress in detached rice leaves. *Plant Growth Reg* 27:189-192.

Yoshiba Y, Kiyosue T, Nakashima K, Yamaguchi-Shinozaki K, Shinozaki K. 1997. Regulation of levels of proline as an osmolyte in plants under water stress. *Plant Cell Physiol* 38:1095-1102.