MCM DESIGN

ISBN: 978-602-9042-11-5

PROCEEDINGS

Udayana University
Press

2nd International Conference on Biosciences and Biotechnology

PAVE THE WAY TO A BETTER LIFE

Udayana University, Bali, Indonesia| 23-24 September 2010

EDITORS:
Yan Ramona (Udayana University)
Yenni Ciawi (Udayana University)
Made Pharmawati (Udayana University)
Anom Sutrisna Wijaya (Udayana University)
Nyoman Sri Budayanti (Udayana University)
Wardhana Suryapratama (Soedirman University)
Edy Kurnianto (Diponegoro University)
I Nyoman Sutarpa Sutama (Udayana University)
Ida Bagus Wayan Gunam (Udayana University)
I Made Mastika (Udayana University)
A.A. Kartini (Udayana University)
I Nyoman Sumerta Miwada (Udayana University)
I Gede Suranjaya (Udayana University)
I Gusti Putu Nugraha Yasa (Udayana University)

ORAL PRESENTATION: AGRICULTURE

PROMOTING GROWTH AND TUBER FORMATION OF POTATO PRODUCTION AT LOWLAND BENGKULU BY APPLYING ANTI-GA (GIBERELLIC ACID) AND LOWERING SOIL TEMPERATURES

Fahrurrozi[1], Usman Kris Joko Suharjo[1], Sigit Sudjatmiko[1], dan Popi S.[2]
[1]Faculty Members, and [2]Student at Agronomi Study Program, Department of Crop Production, Faculty of Agriculture, Universitas Bengkulu, Jl. Kandang Limun, Bengkulu 38001;
Corresponding author: fahrurrozi@unib.ac.id

ABSTRACT

The overall goal of this experiment was to establish a technology for growing potato at the low elevation. There were three groups of experiment with its own separate objective. The first experiment was to determine the best time (1, 2, 3, and 4 week after emergence) for applying retardant at their effective concentration (4 ppm ANZ, 1200 ppm CCC, 50 ppm COU, and 4000 ppm PBZ) for promoting potato tuber formation. The second experiment was to determine the best combination of time for watering potato crops and time for applying retardant (Coumarin) to promote tuber formation. The third experiment was to find out the best mulch type in reducing soil temperatures. Results showed that each retardant had its own best timing for application, 12:00 WIB was the best time for watering potato crops, irrigation significantly reduce maximum soil temperatures, and silver mulch along with organic mulches were the best mulches for reducing maximum soil temperature.

INTRODUCTION

The centre production for potato (*Solanum tuberosum* L.) in Indonesian generally take places in highland altitude, such as Pengalengan, Lembang, and Cipanas (West Java), Dieng Highland (Cebtral Java), Batu (East Java), Brastagi (North Sumatera), and South Sulawesi highland (International Potato Center, 2001). This is agronomically well-understood since potato plants will optimally produce its tuber at the temperature of 17-20 °C (Haynes *et al*., 1988; Stark and Love, 2003; Suharjo, 2006). Several Indonesian researchers, however, have tried to develop technology production of potato in lower altitude in order to increase national production of potato (Sutater *et al*., 1987; Syarif, 2004; Wicaksana, 2001). Unfortunately, the results were unable to answer whether potato grown in lowland produces tubers as good as highland potato production.

According to Suharjo (2006) the main constraint for potato production in lowland altitudes is related to high temperatures, particularly night temperatures and soil temperatures. At high temperatures, the tuber formation (change from stolon to tuber) is significantly (Stark and Love, 2003), and increases the biosynthesis of gibberellic acid (GA) in leaf buds (Menzel, 1983). It has been well reported that GA inhibited the tuber formation (Vreugdenhil *et al*., 1998). Many researchers, however, reported that the negative effects of GA can be removed by anti GA applications, such as CCC (Menzel, 1980; Mardalena, 2006), Ancymidol (Escalante and Langille, 1998), Paclobutrazol (Wang and Langille, 2005), or Coumarine (Andrianie, 2006). High temperatures also has been well-known to increase crop respiration, decrease rate of photosynthesis, decrease assimilate partitioning to roots and tubers, decrease sucrose conversion to starch (Reynold *et al*., 1990; Sarquis *et al*., 1996). These all significantly inhibit growth and tuber formation of potato plants.

High temperature decreased potato production by inhibiting starch synthesis in the tuber (Krauss and Marcheshner, 1984) or decrease the assimilate partitioning to tuber (Basu and Minhas, 1991), and increase assimilate partitioning the above-ground parts (Gawronska *et al*., 1992). In addition, high air temperatures (30-35 °C) have bigger negative effects to the tuber formation than high soil temperatures do (Ewing and Struik, 1992). High soil temperatures will not inhibit the signaling for tuber formation, it will inhibit the development of stolon to become tuber (Jackson, 1999). It is therefore crucially important to decrease temperatures in potato's rizosphere for lowland potato production.

Research conducted by Ewing and Struik (1992); Fernie and Willmitzer (2001); Jackson (1999) indicated that mode of action of tuber formation inhibition by high temperature takes place as a result of increased GA in stolon. This result was confirmed by the applications biosynthesis inhibitor anti-GAs, such as chloroethyltrimethylamonium chloride (CCC) (Jackson, 1999), ancymidol (Jackson and Prat, 1996; Escalante and Langille, 1998). Paclobutrazol and CCC (Kusmawati, 2006), as well as Coumarine (Andriani, 2006) to minimize the negative effects high temperatures.

It is also important to mention, however, that anti-GA may reduced potato growth when it is applied inappropriately. *In vitro* research conducted by Kusmawati, 2006) reported that when CCC is applied at the early stage of potato growth, potato grew well at 0 ppm CCC, decreased at 250 ppm, and completely stopped at 750 ppm, either at 18 °C or 25 °C air temperatures. However, when it is applied on six-week old explants, CCC increased the total tuber number. This increased was getting better at higher concentrations, particularly at high temperatures. Similar results were also reported when coumarine (Andriani, 2006) and the combinations of CCC and cytokinin (Mardalena, 2006) were applied. Those results indicated that the time of anti-GA application is very important to be determined in order to get good tuber formations at high temperature condition. Since GA biosynthesis takes place in leaf buds (Menzel, 1983), the application of anti-GA should be more effective through foliar application would be more efficient than through soil or irrigation. However, which technique is more efficient has not been well documented and need to be further investigated.

The objectives of this experiment are (a) to determine the proper time of application of growth retardants with effective concentration b) to determine the type mulch that effective to decrease the rizosphere temperatures, and c) to determine the effective time for growth retardant application and time of watering to promote tuber formation and development.

METHODS

Serial experiments were conducted in the screen-house and experimental site of Agronomy laboratory, faculty of Agriculture, Universitas Bengkulu from February to October 2008. The experiments were arranged in bi-factorial Randomized Completely Design. This experiment used recommended concentrations of growth retardant from the previous *in vitro* experiments at 30/25 °C, i.e., 4 ppm Ancymidol, 4000 ppm Paclobutrazol, 1200 ppm CCC, and 50 ppm Coumarin. Data were analyzed with Analysis of Variance and DMRT at 5%.

(1) Evaluation of time of growth retardant's application. Four types of growth retardant with its respective effective concentration were applied to potato plants grown in polybag at 1, 2, 3, and 4 weeks after emergence.

(2). Evaluation of growth retardant application and time of watering. Four types of growth retardant with its respective effective concentration were applied to potato plants grown in polybag at 1, 2, 3, and 4 weeks after emergence in combinations with time of plant watering.

(3). Evaluation of mulch application. Plastic mulches (red plastic mulch, transparent plastic mulch, black plastic mulch, and black-silvered plastic mulch), and organic mulches (rice straw and hulk) were used to reduce rizosphere temperatures of potato plants grown in polybags at 10 m altitude.

RESULTS AND DISCUSSION

Time of Growth Retardant Application

Results indicated that four weeks after plant emergence could be considered as the ideal time for application the applications of growth retardant to promote tuber growth and formation (Table 1), except for Ancymidol (4 ppm) can be applied at anytime. Four-weeks old of potato plants generally have 6-8 leaves where foliar application of retardant could effectively absorbed by plants.

Table 1. Effects of growth retardant and time of retardant applications on tuber formation (tuber number)

Type of Growth Retardant	Time of application (weeks after emergence)			
	1	2	3	4
Ancymidol	7.1 c	8.3 d	8.4 d	8.7 d
Paclobutrazol	3.7 a	4.1 a	3.9 a	5.7 b
CCC	5.3 b	7.6 c	7.9 cd	7.2 c
Coumarin	5.9 bc	5.0 ab	5.6 b	5.7 b
Average	5.4	6.3	6.5	6.8

Mean treatments followed by the same letter in the same column are not significantly different according to DMRT at 5 %

Table 2. Effects of growth retardant and time of retardant applications on total tuber weight (g)

Type of Growth Retardant	Time of application (weeks after emergence)			
	1	2	3	4
Ancymidol	4.64 a	4.22 a	2.21 b	**2.41 b**
Paclobutrazol	3.72 a	4.13 a	0.00 b	**0.00 b**
CCC	5.12 a	3.81 ab	2.61 b	**3.13 ab**
Coumarin	4.34 a	3.12 b	0.00 b	**0.00 c**
Average	4.43	5.3	2.41	2.77

Mean treatments followed by the same letter in the same column are not significantly different according to DMRT at 5 %

Table 3. Effects of growth retardant and time of applications on tuber diameter (cm)

Type of Growth Retardant	Time of application (weeks after emergence)			
	1	2	3	4
Ancymidol	1.21 a	1.16 a	0.53 b	**0.65 b**
Paclobutrazol	1.00 a	0.88 a	0.00 c	**0.00 b**
CCC	0.34 b	0.29 b	0.67 a	**0.23 b**
Coumarin	0.72 a	1.15 b	0.00 b	**0.00 c**
Average	0.82		0.23	0.22

Mean treatments followed by the same letter in the same column are not significantly different according to DMRT at 5 %

Combination between Time of Growth Retardant Application and Watering

Watering significantly decreased the maximum rizosphere temperatures, but not the minimum temperatures (Table 4). Although the minimum temperatures did not decreased, time of watering significantly affected the number and the quality of tubers (Table 5 and Figure 1).

We recommend that retardants be applied at four weeks after plant emergence, e combined with day time irrigation, as well as by using the organic mulch or black-silvered plastic mulch.

REFERENCES

Andriani T. **2006**. Pertumbuhan dan Pembentukan Um bi Mikro Kentang pada beberapa Taraf Coumarine dan Dua Suhu Inkubasi (18 dan 25 °C). Skripsi S-1 Jurusan Budidaya Pertanian, Fakultas Pertanian UNIB (*tidak dipublikasikan*).

Badan Penelitian dan Pengembangan Pertanian. **2002**. Kentang prosesing untuk agroindustri. *Warta 24 (2): 1-3.*

Biro Pusat Statistik. **2003**. Statistik Pertanian Hortikultura Bengkulu. BPS Bengkulu. Bengkulu.

Brown CR. **2005**. Antioxidant in potato. *Amer.J. Potato Res. 83 (2): 163-172.*

Basu PS and Minhas JS. **1991**. Heat tolerance and assimilate transport in different potato genotypes. *J. Exp. Bot. 42(240): 861-866.*

Ekwansyah D. 2006. Pengaruh jumlah buku stek dan dosis N pada pembentukan umbi mini kentang varitas Granola di dataran tinggi. Skripsi S-1 Jursan Budidaya Pertanian, Faperta UNIB (*tidak dipublikasikan*).

Escalante BZ and Langille AR. **1995**. Role of growth regulators in *in vitro* rhizome growth of potato. *HortSci. 30 (6): 1248-1250.*

Escalante BZ and Langille AR. **1998**. Photoperiod, temperature, gibberelin, and an anti-gibberellin affect tuberization of potato stem segments *in vitro*. *HortSci. 33(4) 701-703.*

Gawronska H, Thornton MK, and Dwelle RB. **1992**. Influence of heat stress on dry matter production and photoassimilate partitioning by four potato clones. *Amer. Potato J. 69: 653-665.*

Gunarrtha. **1999**. Model dinamik pertumbuhan mentimun Jepang: Kajian Efek TemperaturTtanah. *Agrivita 20: 7-12.*

Gusmin E. 1996. Pengaruh berbagai jenis mulsa terhadap pertumbuhan dan hasil mentimum. Skripsi S-1 Fakultas Pertanian UNIB *(Tidak dipublikasikan).*

Haynes KG, Haynes FL, and Swallow WH. **1988**. Temperature and photoperiod effects on tuber production and specific gravity in diploid potatoes. *HortSci. 23(3): 562-565.*

Hill DE, Hankin L and Stephens GR. **1982**. Mulches: Their effects on fruit set, timing and yield of vegetables. *Com. Agr. Exp. Sta. Bull. 805.*

International Potato Center. **2001**. World Potato Facts. International Potato Center. Lima. Peru.

Jackson SD. **999**. Multiple signaling pathways control tuber induction in potato. *Plant Physiol. 119:1-8.*

Ku SB, Edward GE and Tanner CB. **1977**. Effect of light, carbon dioxide, and temperature on photosynthesis, oxygen inhibition of photosynthesis, and transpiration in *Solanum tuberosum*. *Plant Physiol. 59: 868-872.*

Kincaid DC, Wastermann DT and Trout TJ. 1993. Irrigation and soil temperature effects on Russet Burbank quality. *Amer. Potato J. 70: 711-723.*

Kumar D and Wareing PF. **1974**. Studies on tuberization of *Solanum andigena*. *New Phytol. 73: 833-840.*

Kusmawati L. **2006**. Pertumbuhan dan Pembentukan Umbi Mikro secara *in vitro* dengan Pemberian 5 Konsentrasi Chlorocholine Chloride (CCC) pada dua suhu inkubasi (18 dan 25°C). Skripsi S-1 Jurusan Budidaya Pertanian, Fakultas Pertanian UNIB (*tidak dipublikasikan*).

Kusumo S dan Sutater T. **1991**. Tumpangsari di pertanaman kentang dataran medium. *J.Hort. 1(2): 22-27.*

Manrique LA, Bartholomew DP, and Ewing EE. **1989**. Growth and yield performance of several potato clones grown at three elevations in Hawaii. I. Plant Morphology. *Crop Sci. 29: 663-370.*

Mardalena Z. **2006**. Pembentukan Umbi Mikro secar *in vitro* pada Dua Suhu Inkubasi (18 dan 25°C) dengan Perlakuan CCC dan Coumarine. Skripsi S-1 Jurusan Budidaya Pertanian, Fakultas Pertanian UNIB (*tidak dipublikasikan*).

Martinez-Garcia JF, Garcia-Martinez JL, Bou J, and Prat S. **2002**. The interaction of gibberellins and photoperiod in the control of potato tuberization. *J.Plant Growt Reg. 20: 377-386*

Menzel CM. **1980**. Tuberization in potato at high temperatures: response togibberellin and growth inhibitors. *Ann. Bot. 46; 259-265.*

Menzel CM. **1983**. Tuberization in potato at high temperatures: Gibberellin content and transport from buds. *Ann. Bot. 52: 697-702.*

Reyes LF, Miller JC, and Cisneros-Zevallos L. **2005**. Antioxidant capacity, anthocyanin and total phenolics in purple- and red-flesh potato (*Solanum tuberosum*). *Amer.J. Potato Res. 83 (4): 271-276.*

Reynolds MP, Ewing EE and Owens TG. **1990**. Photosynthesis at high temperature in tuber-bearing *Solanum* species. *Plant Physiol. 93: 791-797.*

Sarquis JI, Gonzales H, Hernal-Lugo I. **1996**. Response of two potato clones (*Solanum tuberosum*) to contrasting temperature regimes in the field. *Amer. Potato J. 73: 285-300.*

Sharpe PJH. **1983**. Responses of photosynthesis and dark respiration to temperature. *Ann. Bot. 52 325-343.*

Snyder R and Ewing EE. **1989**. Interative effects of temperature, photoperiod, and cltuvar on tuberization of potato cuttings. *HortSci. 24(2): 336-338.*

Stark JC and Love SL. 2003. Potato Production Systems: a comprehenshive guide for potato production. University of Idaho Extension. Idaho. U.S.A.426pages.

Struik PC, Geerstema J, Custers CHMG. **1989**. Effects of shoot, root, and stolon temperature on the development of the potato (Solanum tuberosum L.) plant. III Development of tubers. *Potato Res. 32: 151-158.*

Suharjo UKJ. **2004**. Use of Polyethylene Glycol (PEG) 8000 for Screening of Potato Genotypes for Water Stress Tolerance. Graduate Disertation at the University of Maine. Orono, U.S.A.

Suharjo UKJ. **2005.** Use of Polyethylene Glycol (PEG) 8000 for in vitro Screening of Potato Genotypes against Water Stress, pp: 133-137. *In* Suprapto, M. P. Yufdy, S.D. Utomo, P.B.Timotiwu, T.R. Basuki, A. Prabowo, dan A. Yani (eds.). Prosiding Lokakarya Nasional Pengembangan Pertanian Lahan Kering 20-21 September 2005. Bandar Lampung, Lampung

Suharjo UKJ. **2006.** Producing potatoes at low elevations: a fact or a fantasy? *Akta Agrosia 9 (1): 1-5.*

Sutarya R, Nurmadi T, dan Sukarso. 2002. Pengembangan Teknologi Produksi Benih Umbi Mikro Kentang yang Bermutu. http://www.dikti.org/p3m/vucer9/02024s.html 14 Februari 2006.

Sutater T, Wiroatmodjo J, Solahuddin S, Nasoetion II, Bey A, dan Nur MA. **1987.** Pertumbuhan dua varietas kentang (Solanum tuberosum L.) di lingkungan dataran rendah. *Forum Pasca Sarjana 10 (1): 1-13.*

Syarif Z. **2004**. Karakteristika pertumbuhan tanaman kentang yang ditopang dengan turus dalam sistem tumpangsari kentang/jagung dengan berbagai waktu tanam jagung di dataran medium. *Stigma 12 (4): 431-436.*

Taiz L and Zeiger E. **1998.** Plant Physiology, 2nd. Sianuer. Massachussetts. 792 pages.

Wang B. **2002**. Physiological Studies on Tuber Development in *Solanum* Species. Graduates Thesis at the University of Maine. Orono, U.S.A.

Wang B and Langille AR. **2005**. Response of a GA-deficient potato mutant to induction and growth regulators as a working model for tuber initiation. *Amer.J. Potato Res. 82 (1): 95* (Abstract).

Wicaksana N. **2001**. Penampilan fenotipik beberapa parameter genetic 16 genotip kentang pada lahan sawah di dataran medium. *Zuriat 12(1): 15-20.*

Xu X, van Lammeren AAM, Vermeer E, and Vreugdenhil D. **1998.** The role of gibberellin, abscisic acid, and sucrose in the regulation of potato tuber formation in vitro. *Plant Physiol. 117: 575-584.*

Vreugdenhil D., Boogard Y, Visser RGF, and de Bruijn SM. **1998**. Comparison of tuber and shoot formation from *in vitro* cultured potato explants. *Plant Cell, Tissue and Organ Culture 53: 197-204*