# Effect of Some Micronutrients on Damage Compensation and Yield Parameters in Okra

Syed Shahzad Ali[1,*], Wazhar Ali Pusio[2], Huma Rizwana[1], S. Shahbaz Ali[1], Shifarash Ghouri[1] and S. Sohail Ahmad[1]

*[1]Department of Entomology; [2]Department of Livestock Management, Sindh Agriculture University Tandojam, Pakistan*

**Abstract:** The effect of micronutrients on damage compensation and yield components of okra was investigated, using three foliar sprays (at 15 days interval) of Effective microorganisms (EM-1), Wokozim and Kissan Supreme Tonic (KST). Weekly observations on sucking complex (thrips, jassid, whitefly) and pod borers were carried out. The yield $ha^{-1}$ of green pods was recorded to ascertain the compensation of the damage done by the insect pests. The damage done by sucking complex and borers was markedly compensated by the micronutrients, and okra pod yield in EM-1, Wokozim and KST sprayed plots were 10911, 9507 and 8948 kg $ha^{-1}$, respectively as compared to 8034 kg $ha^{-1}$ in control. The effect of micronutrients on crop growth and subsequently on sucking complex infestation was significant and thrips, jassid, whitefly and borer infestation was relatively lesser in plots sprayed with micronutrient as compared to the control. KST was most effective in damage compensation of sucking complex and borers with highest okra green pod yield ($P<0.01$), followed by Wokozim and EM-1 when compared with control.

**Keywords:** Okra, micronutrients, sucking complex, okra yield.

## INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) Moench, is grown throughout the tropical and warm temperate regions of the world for its fibrous pods eaten as a vegetable [1]. Okra is attacked by a number of insect pests i.e. sucking complex, bollworm complex, hoppers and certain mites from sowing till harvest [2]. Infestation of more than 10 insect pests on okra has been recorded which causes drastic reduction in the yield of okra. The pests included are fruit and shoot borers, leaf roller, sucking and chewing insects, root feeding insects and mites. Some of them like; aphids, jassids, whitefly, thrips, and mites suck the cell sap of plant resulting destruction of plant vigour. During the wet season, crop is tolerant to the most insect pests but may be affected by disease; while during dry season leafhoppers and aphids may cause damage [3].

Chemical control of insect pests is generally practiced for higher gains but due to shorter interval in periodical harvest, use of chemicals alone is not advisable. Under such situation, it becomes pertinent to look for alternatives which are effective and eco-friendly. Use of nutrient amendments applied to soil not only enhance the nutrient status but also reduces the pest incidence [4]. Literature showed that very little work has been done on the effect of organic and inorganic sources of nutrients on insect pests of okra. Nutrients in organic form were applied before sowing of okra with basal P and K, while splits of N were applied at sowing, flowering and pod formation. Nymph and adult aphid (*Aphis gossypii*) and adult whitefly (*Bemisia tabaci*) were found infesting okra; but aphid population was significantly lower (15.28 aphids/leaf) under 75% dose of nutrients from neem cake + 25 % chemical fertilizer. 25-75% of organic nutrients in conjunction with normal inorganic nutrients significantly reduced aphid incidence over straight fertilization. [5-7a] explored the utility of nutrients for managing the pests of okra. Sucking insect population was more or less same in untreated (control) and the plots received either with 25% organic nutrients. Jassid *A. biguttula biguttula* population like aphids in 75% organic nutrients and 25% chemical fertilizers was significantly reduced (2.75 leafhoppers / 3 leaves) over chemical fertilizers alone. Whitefly, *B. tabaci* population suppressed when okra was sprayed with 50-75% organic nutrients and rest from inorganic nutrients; only chemical fertilizers registered maximum (5.40 whiteflies/3 leaves) population of *B. Tabaci* [6]. Maximum (11.33%) weight loss was evident in case of inorganic form of fertilizers applied alone. The impact of organic manures in reducing fruit borer incidence in okra was associated with lower borer infestation when FYM and vermicompost were applied [7b]. There was significant ($P<0.05$) effect of micronutrients application on plant height, number of fruiting bodies and volume of bolls in comparison to control on okra; no significant effect of micronutrient on multiplication of jassid and whitefly was observed. Significantly lower population of thrips and percent infestation of bollworms were recorded on micronutrient sprayed cotton compared

*Address corresponding to this author at the Department of Entomology, Sindh Agriculture University Tandojam, Pakistan; Tel: 0344-3094933;
E-mail: alisyedshahzad75@gmail.com

ISSN: 1814-8085 / E-ISSN: 1927-5129/12 

with control plots. Application of micronutrients also did not have any significant effect on the maturity of cotton [8]. In view of the significance of nutrients on the infestation of various insect pests, the study was carried out to examine the effect of some micronutrients on damage compensation and yield parameters in okra.

## MATERIALS AND METHODS

### Experimental Design

Experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments including control (check) and was replicated three times. The treatment size was 13.5 $m^2$. Experiment was conducted at the Crop Protection Faculty, Sindh Agriculture University Tandojam during summer 2008.

### Agronomic Practices

Okra variety Mirpurkhas-I was sown on May 03, 2008 by dibbling method on furrows. The distance between plant to plant was 22.5 cms and row to row 75 cms, respectively. Two bags of DAP per acre were applied at the time of sowing by mixing in soil while seed bed was prepared; while three applications of Nitrogen (Urea) fertilizer were applied on second, fourth and sixth irrigations.

### Application of Micronutrients

The application of effective microorganisms, EM-1, Wokozim and Kissan Supreme Tonic was carried out three times at the interval of 15 days. The application of effective microorganisms was done using fertigation technique, while the application of Wokozim and Kissan Supreme Tonic micronutrients was applied on foliarwith the helpof Knapsack hand sprayer. Micronutrients were sprayed at recommended doses described at the labels of the respective company products.

T1= Effective Microorganisms (EM-1) (25 to 30 litre / acre)

T2= Wokozim (300 ml / 100 litre of water)

T3= Kissan Supreme Tonic (500 ml / acre)

T4= Control

### Application of Insecticides

When the pest population reached near economic injury level the pesticides were sprayed in each plot. The first spray of Confidor (Imidacloprid, 200 SL) was done against thrips and jassid on 15th July at recommended doses 250m/acre, while the second application of insecticides was done with Bifenthrine (Talstar, 500 ml/acre) at the recommended dose against the whitefly. Similarly, the third application against the shoot and fruit borers was done with Spintor (40cc/acre) following the dose labeled at their packing.

### Collection of Data on Insect Infestation

#### *Sucking Insects*

The observations started 45 days after planting and weekly data on each of the insect pest infestation were maintained. Observations on sucking complex such as;

Whitefly, Thrips and Jassids were recorded on the basis of five randomly selected plants per treatment and five leaves were taken at random from each selected plant (one from top, two from middle and two form bottom portion).

### Shoot and Fruit Borers

Observations on the fruit borer *Earias vittella* (F.), infestation were initiated 55 days after sowing and were taken once a week. Five plants per treatment were selected at random and observations were recorded on total number of fruiting bodies and on the basis of fruit borer infested fruiting bodies, the percent infestation was worked out.

### Method of Harvesting

The fruits of okra were harvested at certain intervals and weight of the produce was carefully recorded for each experimental unit in each replication. Finally, the fruit yield per hectare was worked out on the basis of pod yield per plot to ascertain the effect of micronutrients on fruit yield per plot and per hectare.

The data was subjected to the analysis of variance (ANOVA) and means were separated by LSD test at P= 0.05 and P= 0.01, using MSTAT-C software (Michigan State University, 1982).

## RESULTS AND DISCUSSION

### Thrips, *Scirtothrips dorsalis* Hood, 1919

Thrips population on different treatments is shown in Table **1** indicate that the pest population was almost uniformly distributed in different micronutrients applied

**Table 1: Seasonal Thrips Population on Okra as Influenced by Application of Various Micronutrients**

| Observation Date | T1=Effective Microorganisms | T2=Wokozim | T3=Kissan Supreme Tonic | T4=Control |
|---|---|---|---|---|
| 13th July 08 | 0.03 | 0.03 | 0.03 | 0.04 |
| 20th July 08 | 0.43 | 0.38 | 0.34 | 0.51 |
| 27th July 08 | 1.25 | 1.11 | 0.99 | 1.48 |
| 3rd August 08 | 2.09 | 1.86 | 1.66 | 2.49 |
| 10th August 08 | 3.26 | 2.90 | 2.58 | 3.88 |
| 17th August 08 | 1.80 | 1.60 | 1.43 | 2.15 |
| 24th August 08 | 5.78 | 5.15 | 4.58 | 6.88 |
| 31st August 08 | 3.16 | 2.81 | 2.50 | 3.76 |
| 7th September 08 | 5.78 | 5.15 | 4.58 | 6.88 |
| 14th September 08 | 3.33 | 2.97 | 2.64 | 3.97 |
| 21st September 08 | 3.57 | 3.18 | 2.83 | 4.25 |
| 05th October 08 | 1.55 | 1.38 | 1.23 | 1.85 |
| 12th October 08 | 2.05 | 1.83 | 1.62 | 2.44 |
| Avg | 2.62 b | 2.33 c | 2.08 d | 3.12 a |

| | TREATMENTS | OBS. DATES |
|---|---|---|
| S.E. | 0.1039 | 0.1873 |
| LSD 0.05 | 0.2054 | 0.3703 |
| LSD 0.01 | 0.2713 | 0.4891 |
| P-Value | 0.0000 | 0.0000 |
| CV% | 18.07 | |

treatments and during different weeks of observation. The analysis of variance of data showed that there was significant effect of application of micronutrients (F=37.14; DF=3, 155; P<0.01) and observation dates (F=168.58; DF=12, 155; P<0.01) on thrips population growth. Thrips population fluctuated between less than 1.00 and more than 6.00 thrips per leaf in different treatments.

**Jassid, *Amrasca (Amrasca) biguttula* (Ishida, 1912)**

The Table **2** shows population of jassid on different observation dates and micronutrients applied. The analysis of variance of data showed that there was significant effect of application of micronutrients (F=23.40; DF=3, 155; P<0.01) and observation dates (F=60.04; DF=12, 155; P<0.01) on jassid population. However, jassid population remained below 1.00, per leaf on different treatment plots throughout the study period.

**Whitefly, *Bemisia tabaci* (Gennadius, 1889)**

Whitefly population fluctuation is shown in Table **3**. The results indicate that there was significant effect of application of micronutrients and observation dates on whitefly population. The analysis of variance of data showed that there was significant effect of application of micronutrients (F=43.60; DF=3, 155; P<0.01) and observation dates (F=36.88; DF=12, 155; P<0.01) on whitefly population growth. Whitefly population fluctuated between remained between 0.02 and 1.14 whiteflies per leaf in different treatments and at different observation dates.

**Fruit Borer, *Earias vittella* (Fabricius 1794)**

Fruit borer population on okra variety Mirpurkhas-I under different treatments shown in Table **4** indicate that the pest population was almost uniformly distributed in different micronutrients applied treatments and during different weeks of observation. The analysis of variance of data showed that there was significant effect of application of micronutrients (F=15.59; DF=3, 155; P<0.01) and observation dates (F=29.91; DF=12, 155; P<0.01) on fruit borer population growth. Fruit borer population fluctuated between 1.37 and 4.39 fruit borers per plant in different treatments on okra.

**Green Pod Yield (kg ha$^{-1}$)**

Finally, the yields of okra fruit for all pickings were accumulated per plot, and on the basis of pod yield per

**Table 2: Seasonal Jassid Population on Okra as Influenced by Application of Various Micronutrients**

| Observation Date | T1=Effective Microorganisms | T2=Wokozim | T3=Kissan Supreme Tonic | T4=Control |
|---|---|---|---|---|
| 13th July 08 | 0.02 | 0.01 | 0.01 | 0.02 |
| 20th July 08 | 0.15 | 0.13 | 0.12 | 0.18 |
| 27th July 08 | 0.29 | 0.25 | 0.23 | 0.34 |
| 3rd August 08 | 0.31 | 0.28 | 0.25 | 0.37 |
| 10th August 08 | 0.49 | 0.43 | 0.39 | 0.58 |
| 17th August 08 | 0.37 | 0.33 | 0.29 | 0.44 |
| 24th August 08 | 0.58 | 0.51 | 0.46 | 0.69 |
| 31st August 08 | 0.47 | 0.42 | 0.38 | 0.56 |
| 7th September 08 | 0.41 | 0.37 | 0.33 | 0.49 |
| 14th September 08 | 0.37 | 0.33 | 0.29 | 0.44 |
| 21st September 08 | 0.25 | 0.22 | 0.20 | 0.30 |
| 05th October 08 | 0.23 | 0.21 | 0.18 | 0.28 |
| 12th October 08 | 0.21 | 0.18 | 0.16 | 0.24 |
| Avg | 0.32 b | 0.28 c | 0.25 c | 0.38 a |

| | TREATMENTS | OBS. DATES |
|---|---|---|
| S.E. | 0.0164 | 0.0296 |
| LSD 0.05 | 0.0324 | 0.0585 |
| LSD 0.01 | 0.0428 | 0.0772 |
| P-Value | 0.0000 | 0.0000 |
| CV% | 22.57 | |

**Table 3: Seasonal Whitefly Population on Okra as Influenced by Application of Various Micronutrients**

| Observation Date | T1=Effective Microorganisms | T2=Wokozim | T3=Kissan Supreme Tonic | T4=Control |
|---|---|---|---|---|
| 13th July 08 | 0.02 | 0.02 | 0.02 | 0.03 |
| 20th July 08 | 0.18 | 0.17 | 0.15 | 0.31 |
| 27th July 08 | 0.34 | 0.33 | 0.28 | 0.66 |
| 3rd August 08 | 0.37 | 0.36 | 0.31 | 0.73 |
| 10th August 08 | 0.58 | 0.57 | 0.48 | 0.93 |
| 17th August 08 | 0.43 | 0.42 | 0.36 | 0.72 |
| 24th August 08 | 0.68 | 0.67 | 0.56 | 1.14 |
| 31st August 08 | 0.56 | 0.55 | 0.46 | 0.93 |
| 7th September 08 | 0.68 | 0.67 | 0.56 | 0.72 |
| 14th September 08 | 0.43 | 0.42 | 0.36 | 0.72 |
| 21st September 08 | 0.29 | 0.29 | 0.24 | 0.49 |
| 05th October 08 | 0.28 | 0.27 | 0.23 | 0.32 |
| 12th October 08 | 0.24 | 0.24 | 0.20 | 0.28 |
| Avg | 0.39 b | 0.38 b | 0.32 bc | 0.61 a |

| | TREATMENTS | OBS. DATES |
|---|---|---|
| S.E. | 0.0274 | 0.0494 |
| LSD 0.05 | 0.0542 | 0.0977 |
| LSD 0.01 | 0.0716 | 0.1291 |
| P-Value | 0.0000 | 0.0000 |
| CV% | 28.30 | |

**Table 4: Seasonal Borers Population on Okra as Influenced by Application of Various Micronutrients**

| Observation Date | T1=Effective Microorganisms | T2=Wokozim | T3=Kissan Supreme Tonic | T4=Control |
|---|---|---|---|---|
| 13th July 08 | 2.70 | 2.44 | 2.20 | 2.58 |
| 20th July 08 | 2.55 | 2.31 | 2.08 | 2.43 |
| 27th July 08 | 2.75 | 2.49 | 2.25 | 2.62 |
| 3rd August 08 | 3.44 | 3.11 | 2.81 | 3.28 |
| 10th August 08 | 2.12 | 2.24 | 2.02 | 2.36 |
| 17th August 08 | 2.84 | 2.57 | 3.13 | 3.65 |
| 24th August 08 | 3.22 | 2.90 | 3.76 | 4.39 |
| 31st August 08 | 2.71 | 2.45 | 2.77 | 3.23 |
| 7th September 08 | 2.72 | 2.46 | 2.72 | 3.17 |
| 14th September 08 | 3.05 | 2.29 | 3.04 | 3.55 |
| 21st September 08 | 2.59 | 2.34 | 2.11 | 2.47 |
| 05th October 08 | 2.11 | 1.61 | 1.46 | 1.70 |
| 12th October 08 | 1.95 | 1.51 | 1.37 | 1.60 |
| Avg | 2.67 b | 2.36 c | 2.44 c | 2.85 a |

| | TREATMENTS | OBS. DATES |
|---|---|---|
| S.E. | 0.0799 | 0.1440 |
| LSD 0.05 | 0.1579 | 0.2847 |
| LSD 0.01 | 0.2086 | 0.3761 |
| P-Value | 0.0000 | 0.0000 |
| CV% | 13.66 | |

plot, the pod yield per hectare was worked out. The results (Table **5**) indicated that the damage done by the sucking complex and borers was remarkably compensated by the commercial micronutrient product named as Kissan Supreme Tonic with highest green edible pod yield of 10911 kg $ha^{-1}$, while a similar micronutrient product marketed in the name of Wokozim resulted green pod yield of 9507 kg $ha^{-1}$ ranking second. The Effective Micronutrients generally known as EM Technology material used through fertigation produced average green pod yield of 8948 kg $ha^{-1}$, while the green pod yield in plots left untreated (control) was lowest i.e. 8034 kg $ha^{-1}$.

## DISCUSSION

Insect pests including sucking complex, borers and other major and minor insect pests cause severe economic losses to okra crop and the farmer's crop is

**Table 5: Green Pod Yield Per Plot/Per Hectare (kg) of Okra as Affected by Application of Various Micronutrients**

| Treatments/ Micronutrients | RI | | RII | | RIII | | Mean | |
|---|---|---|---|---|---|---|---|---|
| Treatments/ Micronutrients | Yield $plot^{-1}$ | Yield $ha^{-1}$ | Yield $plot^{-1}$ | Yield $ha^{-1}$ | Yield $plot^{-1}$ | Yield $ha^{-1}$ | Yield $plot^{-1}$ | Yield $ha^{-1}$ |
| T1 = Effective Microogranisms (EM-1) | 12.08 | 8945 | 12.78 | 9468 | 11.38 | 8431 | 12.08 | 8948 b |
| T2 = Wokozim | 12.27 | 9092 | 13.43 | 9945 | 12.80 | 9483 | 12.83 | 9507 b |
| T3 = Kissan Supreme Tonic | 14.43 | 10689 | 15.14 | 11213 | 14.62 | 10832 | 14.73 | 10911 a |
| T4 = Control | 10.93 | 8093 | 10.80 | 7998 | 10.82 | 8012 | 10.85 | 8034 c |

| | |
|---|---|
| S.E. | 233.89 |
| LSD 0.05 | 572.82 |
| LSD 0.01 | 867.14 |
| P-Value | 0.0001 |
| CV% | 3.06 |

always at risk due these insects. Moreover, little work has been done to find out the solutions, particularly to compensate the damage done by the insect pests. The present study was therefore, carried out to investigate the effect of some micronutrients on damage compensation and yield of okra. In this study, Effective microorganisms (EM-1), Wokozim and Kissan Supreme Tonic (KST) were applied three times at the interval of 15 days. The damage done by the sucking complex and borers was remarkably compensated by the micronutrients with increasing pod yield of 10911, 9507 and 8948 kg $ha^{-1}$ when treated with EM-1, Wokozim and KST, respectively as compared to 8034 kg $ha^{-1}$ in control. The effect of micronutrients on crop growth and subsequently on sucking complex infestation was significant. Thrips, jassid, whitefly and borer infestation was relatively lesser than the control plots. Kissan Supreme Tonic improved green pod yield remarkably to compensate the damage done by the sucking complex and borers, followed by Wokozim and EM-1 material when compared with control. These results are fully supported by [4], who concluded from their studies that the use of nutrient amendments applied to soil not only enhance the nutrient status but also reduces the pest incidence. Moreover, [6, 7b, 9, 10], explored the utility of nutrients for managing the pests of okra. Little work has been done on the effect of organic and inorganic sources of nutrients on insect pests of okra. Pod borers appeared at initiation of flowers in okra crop and the average seasonal borer population in EM-1, Wokozim and KST applied plots were 2.67, 2.36 and 2.44/leaf as compared to 2.85/leaf in control. Similar studies have also been carried out by [7a-7c], who reported that fruit borer (*Earias vittella*) infestation to okra fruits was higher when only NPK fertilizers were applied and the borer attack reduced considerably with application of micronutrients as foliar sprays. Aphid population recorded significantly lower (15.28 aphids/leaf) under 75 % dose of nutrients from neem cake+25 % chemical fertilizer. Organic nutrients applied @ 25 to 75% recommended dose in conjunction with remaining doses from inorganic fertilizers exhibited significantly low incidence of *A. gossypii* over straight fertilizer [6], studied that only chemical fertilizers registered maximum (5.40 whiteflies/ 3 leaves) population of *B. Tabaci*. Maximum (11.33%) weight loss was evident in case of inorganic form of fertilizers applied alone. The impact of organic manures in reducing fruit borer incidence in okra observed in present study is in agreement with the report of [7a], who showed lower percentage of fruit borer infestation in okra when the plants were treated with farmyard manure and vermicompost. In a similar investigation [7b, 11a,b], studied effect of micronutrients on plant growth and insect infestation of cotton crop and indicated that there was significant ($P<0.05$) effect of application of micronutrients on plant height, number of fruiting bodies and volume of bolls in comparison to control.

## CONCLUSIONS

1. The effect of micronutrients on crop growth and subsequently on sucking complex infestation was significant and thrips, jassid, whitefly and borer infestation was relatively lesser than the control plots.

2. Kissan Supreme Tonic followed is an effective micronutrient composition to develop relative tolerance to sucking insects and borer infestation, followed by Wokozim and Effective microorganisms.

3. Kissan Supreme Tonic improved green pod yield remarkably to compensate the damage done by the sucking complex and borers, followed by Wokozim and EM-1 material when compared with control.

## RECOMMENDATIONS

On the basis of findings from the present research, it is suggested that for effective damage compensation in okra, the crop may be sprayed with Kissan Supreme Tonic (KST) atleast three times at 15 days interval after pod formation.

## REFERENCES

[1] Wikipedia. 2009. Okra: From Wikipedia the free Encyclopedia, 16-7-2009,12.37am: 1-3.

[2] Ashraf M. Arthropods associated with okra, *Abelmoschus esculentus* L. crop M. Sc. Thesis, Department of Entomology submitted to Sindh Agriculture University, Tandojam 1980; 51.

[3] Praveen PN, Rao SN, Dhanapani N. Management of insect pests in okra, *Abelmoschus esculentus* (L.). J Vegetable Crop Prod 2002; 7(2): 72-79.

[4] Kavitharaghavan RR, Vijaya RC. Effect of organic sources of nutrients on sucking pest complex of brinjal. A Paper Presented In: National Seminar on Biodiversity and Insect Pest Management Chennai February 3-4 2005.

[5] Ahmed HS, Khan AMA, Habib A. Efficacy of neem oil and synthetic growth regulators on control of okra insect pests as compared to chemical pesticides. J Sustainable Agric Environ 1995; 5(1/2): 232-45.

[6] Surekha J, Rao PA. Management of aphids on bhendi with organic sources of NPK and certain insecticides. Andhra Agric J 2001; 48: 56-60.

[7] (a) Prakash YS, Bhadoria PBS, Amitav R.. Relative efficiency of organic manures in improving resistance and pest tolerance of okra. Ann Agric Res 2002a; 23: 525-31. (b) Prakash A, Wani AH, Alam MM. Effect of soil amendment with urea coated 'Nimin' and oils of neem, castor and rocket salad on the root-knot nematode Meloidogyne incognita and growth of okra. Tests Agrochem Cultiv 2002b; 23: 34-35. (c) Prakash YS, Amitava R, Bhadoria PBS. Effect of FYM, vermicompost. and micronutrients on insect infestation and fruit yield of okra. Ann Agric Res 2002c; 25: 634-39.

[8] Hussain M. Effect of micronutrients on plant growth and insect [jassid, whitefly and thrips] infestation of cotton crop. Project Report, Pakistan Agricultural Research Council, NARC, Islamabad, 2001; 1-50.

[9] Patil KB. effect of micro nutrients on growth and yield of okra. J Soils Crops 2004; 14(1): 211-12.

[10] Patil KB. Effect of micro nutrients on yield of okra (*Abelmoschus esculentsus* (L.) Meench). Orissa J Horticult 2001; 20(2): 118.

[11] (a) Ranjan A, Chaudhary V. Effect of integrated nutrient management of growth and yield of okra (*Abelmoschus eschlentus*). J Appl Biol 2006a; 16(1/2): 11-13. (b) Ranjan A, Chaudhary V. Response of okra to organic and inorganic fertilization. J Appl Biol 2006b; 16(1/2): 14-16.

Received on 18-09-2012 Accepted on 15-10-2012 Published on 22-10-2012

http://dx.doi.org/10.6000/1927-5129.2012.08.02.57