Characterization, diversity, and effectiveness phosphate solubilizing bacteria from the soil and rhizosphere on the growth of *Glycine max* L. in greenhouse

S Purwaningsih¹*, E Sutisna¹ and A A Nugroho¹

¹ Microbiology Division, Research Center for Biology, Indonesian Institute of Sciences
Jl. Raya Jakarta-Bogor Km 46 CSC, Cibinong, West Java. 16911.Fax: (021) 8765062

*Corresponding author e-mail: sipur2005@yahoo.co.id

Abstract. The research was conducted to know the diversity, characterization, and effectiveness of phosphate solubilizing bacteria from the soil and rhizosphere on the growth of *Glycine max* L. in a greenhouse. The study aims to know the population, get the pure culture of phosphate solubilizing bacteria, and obtain isolates potential of the soybean growth. Isolation was done in medium Pycoskvaya. The growth characteristic of pure culture was observed using Pikovskaya medium; the clear zone surrounding the colonies indicates that the phosphate in the medium was hydrolyzed. The experiment aimed to assess the potency of the Phosphate Solubilizing Bacteria to increase the growth of Glycine max L., using sand media sterilized. The strain used selected; there were ten isolates used in this research. Parameters of the investigation were the dry weight of canopy, roots, root nodules, total plants, number of nodules, and “Symbiotic Capacity.” The highest population was found from the sample soil from the rhizosphere with *Sechium edule* plant. Forty-five gave of pure culture, wholly able to hydrolyzed phosphate. This study showed that the strain number of 9 BTLP(2) (isolate from *Zea mays* plant) had given the best results on the growth of *Glycine max* L.

Keywords: Phosphate Solubilizing Bacteria, Biofertilizer, *Glycine max* L.

1. Introduction
Sulawesi Island is one of the major islands in Indonesia, which has small islands around it, one of which is the island of Buton. The island is the potential for the development of agriculture, plantation, and forest conservation. Development and improvement of crop production need to be supported by efforts to improve soil fertility, it is necessary to attempt to dig biological resources, especially the types of microbes associated with the fertility of the soil, so it is necessary to do the exploration and collection of the microbial soil conditioner in the area of the island, particularly the type soil bacteria.

Soil fertility and crop productivity in this island area must be supported by data and information about soil bacteria in the region. A soil bacterium increases the soil fertility of many kinds, one of which is phosphate solubilizing bacteria. Phosphate solubilizing bacteria play a role in the enrichment of the soil since these bacteria can break the bonds of phosphate and plays a role in phosphate solubilizing. As well as increasing uptake of phosphate, thus increasing the availability of phosphate, especially on soils acids [1], can dissolve the minerals phosphate through the secretion of organic acids [2] and the enzyme phosphatase [3], as well as play a role in transferring energy, make up a protein, a coenzyme, nucleic acid and compounds other metabolic, can increase the activity of phosphate absorption in plants that lack phosphate [4]. Furthermore, [5] suggested that phosphate solubilizing...
bacteria categorized as free-living bacteria in the soil, as bacterial growth promoters of plants that produce organic acids, enzymes, vitamins, and phytohormones, to improve the growth of plant roots and increases nutrient uptake, in addition to the role inaccessibility in recycling nutrients, antagonistic properties against pathogens, establish and maintain soil structure [6]. The types of microbes are *Bacillus* sp., *Pseudomonas* sp.[7] and others. The growth rate increased after the Leucaena plants by phosphate solubilizing bacteria [8], the use inoculations of phosphate solubilizing bacteria capable of increasing the rice production of about 70% with an average increase of about 15.23 to 28% [9], and inoculation of bacteria *Bacillus megaterium* and *B. circulans* able to increase the production of peanuts, as well as inoculation phosphate solubilizing bacteria can improve P uptake and yield of soybean in Ultisol by 50% [10]. Some types of *Pseudomonas* sp. are beneficial for plant growth, among others, as it can the solubilizing phosphate soil, able to secrete organic acids which can form complexes stabilized with cations binding P in soil and organic acids will lower the pH and breaking the bonds in several forms of phosphate. So that will result in the availability of phosphate in the soil solution, besides phosphate solubilizing bacteria are antagonistic to pathogens roots of plants for produce siderophores and antibiotics, produce substances growth regulators (auxin, gibberellins, and vitamins), and is dominating the root surface, so that shoof microorganisms unbeneificial [11].

To determine the presence of phosphate solubilizing bacteria mentioned above, then do diversity, characterize, and the effectiveness tests of the bacteria mentioned above, hoping we will get the bacteria potential, which will be developed as a biological fertilizer to improve soil fertility.

The purpose of this study was to determine the presence of phosphate solubilizing bacteria and obtain isolates purely as capable of phosphate solubilizing to obtain the bacteria potential, which will be developed as a biological fertilizer to improve soil fertility.

2. Materials and Methods

2.1. Materials

Soil samples were taken from the plant root zone to a depth of 0 - 15 cm at random from the Watulansi village, District Wakorumba National Park North and North Buton (TNBU), Muna, Southeast Sulawesi Province (4.49° – 4.50° South latitude 122.81° -122.83° East Longitude). The medium used for the isolation is to use media Pycovskaya [12] consisting of: Ca₃(PO₄) 2.5 g L⁻¹, (NH₄)₂SO₄ 0.5 g L⁻¹, NaCl 0.2 g L⁻¹, MgSO₄.7H₂O 0.1 g L⁻¹, KCl 0.2 g L⁻¹, Glucose 10 g L⁻¹, Yeast Extract 0.5 g L⁻¹, MnSO₄ 0.0025 g L⁻¹ and FeSO₄ 0.0025 g L⁻¹, Agar 20 g L⁻¹, dH₂O 1000 L, with a pH of 6.8.

2.2. Isolation of Phosphate Solubilizing Bacteria.

Isolation was done by serial dilution of 1 g of soil samples included in 9 mL of saline (0.85% NaCl) in a small test tube, then vortexed, and made serial dilution through 1 mL pipette solution was added 9 mL of NaCl solution 0, 85%. So on until a dilution series 10⁻¹ - 10⁻⁵, pipette 0.1 mL poured in Petri dish which already contains the media as mentioned above, and leveled with a spatula, then incubated at room temperature (27-28°C), each the observed growth and counted the number of colonies. Counting the number of colonies is done by the plate count method [13]. Colonies of phosphate solubilizing bacteria are characterized by forming a clear zone around the colony, then purified by a single streak colony on media Pycovskaya [14].

2.3. Purification and Characterization

Purification is done by colony retrieved by Ose put in sterile distilled water (5 mL), then vortexed, 0.1 mL pipette included in Petri dish containing Pycovskaya medium, leveled with a spatula, then incubated at room temperature (27-28°C), a single colony grown in slant Pycovskaya medium in a test tube (as a pure culture). The isolates were pure, then characterized by growing in Pycovskaya medium in Petri dish, incubated at room temperature (27-280 C), then observed for their ability to phosphate solubilizing, the zone will be the zone marked colored translucent or light around the colony. Observations were made every day for 15 days.
2.4. The effectiveness test.
To test the effectiveness of phosphate solubilizing bacteria inoculation on the growth of soybean plants in a greenhouse, using sterile sand media. The strain been used which have high activity, there were 10 isolates were: 2 BTBP (1), 5 BTBP (1), 12 BTBP (3), 7 BTLP (1), 9 BTLP (2), 12 BTLP (1), 3 BTKP (3), 1 BKLP (3), 3 BTHP (3), 6 BTHP (3). As control plants without inoculation (K1). The design used was a completely randomized design with three replications for each treatment. Crops harvested at 45 days, the parameters observed: dry weight of canopy, root, root nodules, total plant, and a number of nodules. To maintain humidity (24%) watering every day by using rainwater.

3. Results and Discussion
Soil samples from the root zone of fruit plants which consist of 13 samples, showed that the highest phosphate solubilizing bacteria populations on the plant roots guava (*Psidium guajava*). The populations are 36 X 10^5 CFU / g soil. The root zone of the plant's field consists of 14 samples, shows that the highest phosphate solubilizing bacteria populations on the plant roots chayote (*Sechium edule*) are 59 X 10^5 CFU / g soil. The root plants estates consist of 5 samples showed that the highest phosphate solubilizing bacteria populations on the plant roots Pepper (*Piper nigrum*) is 45 X 10^5 CFU / g soil, Then the root zone of forest plants consist of 8 samples shows that the highest phosphate solubilizing bacteria populations on the plant roots *Pometia pinnata* are 27 X 10^5 CFU / g soil (Table 1,2,3, and 4).

| Number of samples | Rhizosphere plants            | The population of phosphate solubilizing bacteria (CFU X 10^5/g soil) | Amount of isolate |
|-------------------|--------------------------------|---------------------------------------------------------------|-------------------|
| 1 BTB             | Mangga (*Mangifera* sp.)       | 21                                                            | 1                 |
| 2 BTB             | Kedondong (*Spondias* sp.)     | 13                                                            | 1                 |
| 3 BTB             | Jeruk (*Citrus* sp.)           | 26                                                            | 1                 |
| 4 BTB             | Jambu mete (*Anacardium occidentale*) | 18                                          | 1                 |
| 5 BTB             | Nanas (*Ananas comosus*)       | 19                                                            | 1                 |
| 6 BTB             | Jambu biji (*Psidium guajava*) | 36                                                            | 1                 |
| 7 BTB             | Sirsak (*Annona squamosa*)     | 17                                                            | 1                 |
| 8 BTB             | Pisang (*Musa paradisiaca*)    | 9                                                             | 1                 |
| 9 BTB             | Papaya (*Carica papaya*)       | 14                                                            | 1                 |
| 10 BTB            | Nangka (*Arthocarpus heterophyllus*) | 19                                       | 1                 |
| 11 BTB            | Rambutan (*Nephelium lappaceum*) | 16                                      | 1                 |
| 12 BTB            | Langsat (*Lansium domesticum*)  | 7                                                             | 1                 |
| 13 BTB            | Without plant                  | 3                                                             | 1                 |

Table 1. The population of phosphate solubilizing bacteria from the roots of fruit trees from the village Watulans, District of North Wakorumba, Muna, Southeast Sulawesi province, at 75 m above sea level.
Table 2. The population of phosphate solubilizing bacteria of plant roots Watulansi village fields, District of North Wakorumba, Muna, Sulawesi southeast, is 75 m above sea level.

| Number of samples | Rhizosphere plants | The population of phosphate solubilizing bacteria (CFU X 10^5/g soil) | Amount of isolate |
|-------------------|--------------------|---------------------------------------------------------------|------------------|
| 1                 | BTL Tomat (Lycopersicon esculentum) | 15                                                          | 1                |
| 2                 | BTL Labu siam (Sechium edule) | 59                                                          | 2                |
| 3                 | BTL Cabe (Capsicum frurescent) | 42                                                          | 1                |
| 4                 | BTL Ubi jalar (Ipomoea batatas) | 14                                                          | 1                |
| 5                 | BTL Singkong (Manihot utilisima) | 19                                                          | 1                |
| 6                 | BTL Dadap (Erythina sp.) | 28                                                          | 1                |
| 7                 | BTL Gamal (Glyciridia sp.) | 23                                                          | 1                |
| 8                 | BTL Kacang hijau (Vigna radiata) | 37                                                          | 1                |
| 9                 | BTL Jagung (Zea mays) | 41                                                          | 2                |
| 10                | BTL Kacang tanah (Arachis hypogaea L) | 26                                                          | 1                |
| 11                | BTL Talas (Alocasia esculenta) | 16                                                          | 1                |
| 12                | BTL Terong (Solanum melongena) | 13                                                          | 1                |
| 13                | BTL Kacang panjang (Vigna unguiculata) | 18                                                          | 1                |
| 14                | BTL Without plant | 6                                                          | 1                |

Table 3. Population phosphate solubilizing bacteria of plant roots Watulans Plantation Village, District of North Wakorumba, Muna, Southeast Sulawesi Province at 75 m above sea level.

| Number of samples | Rhizosphere plants | The population of phosphate solubilizing bacteria (CFU X 10^5/g soil) | Amount of isolate |
|-------------------|--------------------|---------------------------------------------------------------|------------------|
| 1                 | BTK Coklat (Theobroma cacao) | 14                                                          | 1                |
| 2                 | BTK Mrica (Piper nigrum) | 31                                                          | 2                |
| 3                 | BTK Kopi (Coffea sp.) | 19                                                          | 1                |
| 4                 | BTK Kelapa (Cocos nucifera) | 28                                                          | 1                |
| 5                 | BTK Without plant | 9                                                          | 1                |

Table 4. Population phosphate solubilizing bacteria of forest plant roots in TNBU island of Buton, Muna, Southeast Sulawesi province at 375 m above sea level.

| Number of samples | Rhizosphere plants | The population of phosphate solubilizing bacteria (CFU X 10^5/g soil) | Amount of isolate |
|-------------------|--------------------|---------------------------------------------------------------|------------------|
| 1                 | BTH Mangifera sp. | 5                                                          | 1                |
| 2                 | BTH Canarium hirsuta | 14                                                          | 1                |
| 3                 | BTH Pometia pinnata | 27                                                          | 2                |
| 4                 | BTH Dracontomelondao sp. | 19                                                          | 1                |
| 5                 | BTH Delinia cerrata | 21                                                          | 1                |
| 6                 | BTH Myrisrica patua | 13                                                          | 1                |
| 7                 | BTH Cynnamomon sp. | 18                                                          | 1                |
| 8                 | BTH Quercus sp. | 26                                                          | 2                |
Table 5. The ability of phosphate solubilizing bacteria and zoning diameter of 45 pure isolates from soil samples and TNBU Watulansi village, a subdistrict of North Wakorumba, Muna, Southeast Sulawesi Province.

| Isolate number | The location and altitude | Zonation (on day) | Diameter zonation (cm) |
|----------------|---------------------------|-------------------|------------------------|
| 1   | BTBP (1)                  | Watulansi, 75 m asl | 3                      | 0,1                    |
| 2   | BTBP (1)                  | Watulansi, 75 m asl | 4                      | 0,5                    |
| 3   | BTBP (1)                  | Watulansi, 75 m asl | 3                      | 0,3                    |
| 4   | BTBP (1)                  | Watulansi, 75 m asl | 5                      | 0,4                    |
| 5   | BTBP (1)                  | Watulansi, 75 m asl | 3                      | 0,5                    |
| 6   | BTBP (1)                  | Watulansi, 75 m asl | 6                      | 0,2                    |
| 7   | BTBP (1)                  | Watulansi, 75 m asl | 5                      | 0,2                    |
| 8   | BTBP (1)                  | Watulansi, 75 m asl | 3                      | 0,1                    |
| 9   | BTBP (3)                  | Watulansi, 75 m asl | 4                      | 0,3                    |
| 10  | BTBP (1)                  | Watulansi, 75 m asl | 4                      | 0,1                    |
| 11  | BTBP (2)                  | Watulansi, 75 m asl | 5                      | 0,1                    |
| 12  | BTBP (3)                  | Watulansi, 75 m asl | 3                      | 0,5                    |
| 13  | BTBP (1)                  | Watulansi, 75 m asl | 4                      | 0,2                    |
| 1   | BTLP (1)                  | Watulansi, 75 m asl | 3                      | 0,2                    |
| 2   | BTLP (1)                  | Watulansi, 75 m asl | 5                      | 0,4                    |
| 2   | BTLP (2)                  | Watulansi, 75 m asl | 4                      | 0,1                    |
| 3   | BTLP (1)                  | Watulansi, 75 m asl | 6                      | 0,4                    |
| 4   | BTLP (1)                  | Watulansi, 75 m asl | 3                      | 0,1                    |
| 5   | BTLP (1)                  | Watulansi, 75 m asl | 5                      | 0,2                    |
| 6   | BTLP (1)                  | Watulansi, 75 m asl | 4                      | 0,2                    |
| 7   | BTLP (1)                  | Watulansi, 75 m asl | 6                      | 0,6                    |
| 8   | BTLP (1)                  | Watulansi, 75 m asl | 3                      | 0,3                    |
| 9   | BTLP (1)                  | Watulansi, 75 m asl | 5                      | 0,3                    |
| 9   | BTLP (2)                  | Watulansi, 75 m asl | 4                      | 0,7                    |
| 10  | BTLP (1)                  | Watulansi, 75 m asl | 6                      | 0,4                    |
| 11  | BTLP (1)                  | Watulansi, 75 m asl | 7                      | 0,1                    |
| 12  | BTLP (1)                  | Watulansi, 75 m asl | 5                      | 0,6                    |
| 13  | BTLP (1)                  | Watulansi, 75 m asl | 4                      | 0,2                    |
| 14  | BTLP (1)                  | Watulansi, 75 m asl | 3                      | 0,1                    |
| 1   | BTKP (3)                  | Watulansi, 75 m asl | 6                      | 0,1                    |
| 2   | BTKP (1)                  | Watulansi, 75 m asl | 5                      | 0,2                    |
| 2   | BTKP (2)                  | Watulansi, 75 m asl | 7                      | 0,1                    |
| 3   | BTKP (3)                  | Watulansi, 75 m asl | 3                      | 0,8                    |
| 4   | BTKP (1)                  | Watulansi, 75 m asl | 5                      | 0,3                    |
| 5   | BTKP (2)                  | Watulansi, 75 m asl | 4                      | 0,4                    |
| 1   | BKLP (3)                  | TNBU, 375 m asl     | 6                      | 0,6                    |
| 2   | BKLP (1)                  | TNBU, 375 m asl     | 7                      | 0,2                    |
| 3   | BTHP (2)                  | TNBU, 375 m asl     | 6                      | 0,3                    |
| 3   | BTHP (3)                  | TNBU, 375 m asl     | 5                      | 0,8                    |
| 4   | BTHP (1)                  | TNBU, 375 m asl     | 3                      | 0,1                    |
| 5   | BTHP (2)                  | TNBU, 375 m asl     | 4                      | 0,3                    |
| 6   | BTHP (3)                  | TNBU, 375 m asl     | 6                      | 0,5                    |
| 7   | BTHP (1)                  | TNBU, 375 m asl     | 5                      | 0,1                    |
| 8   | BTHP (2)                  | TNBU, 375 m asl     | 3                      | 0,1                    |
| 8   | BTHP (3)                  | TNBU, 375 m asl     | 7                      | 0,1                    |

Note: als = above level sea
Figure 1. The average value Dry Weight of Canopy (DWC), Roots (DWR), Root Nodules (DWRN), and Total Plant (DWTP) soybean plants inoculated with some strain of phosphate solubilizing bacteria (grams).

When compared between samples of soil in the root zone of plants with no plants (as a control) can be said that the population in the root zone of plants is more numerous than those without plants, and this is because the plants do the metabolic activity of roots that issued the metabolites through the roots into the land called exudates. The exudate consists of compounds sugars, amino acids, organic acids, glycoside, nucleotides and alkaline compounds, enzymes, vitamins, and indole compounds, which can be used as bacteria in the soil to survive. As said by [15], the activity of the metabolism and the metabolites are released by the plant through the roots into the soil is a crucial factor in the presence of soil microorganisms in the root zone of plants. In general, increased bacterial activity closer to the surface of plant roots is still affected by the activity of the plant roots [16]. While the sample soil without the plant population is less than that of soil samples at the root zone of plants, because there is no influence of the rhizosphere against microorganisms (such as bacteria), so it is not available compounds / nutrients that can be used to feed the bacteria, so the bacteria shortage of food, which ultimately these bacteria cannot sustain life, then die, resulting in more and at least the bacterial population.

When compared between the plant species, the population is so varied, the population difference between genera and species caused by the metabolic activity of the roots of each plant is different, which causes the differences in the composition of exudate, which will determine the bacterial population in the root zone. As the research results [17] that the population of bacteria in the root zone of plants are all far more than grain crops. One gram of soil from plant roots clover contains 7 to 8 million bacteria, while the barley plants containing 5 to 6 million and plant sugar beets 1 to 2 million.

This research was also supported by the results [28] that 27 of 32 samples of surface soil and around the plant roots have bacterial populations more than the ground inside and outside the roots. In addition, factors of soil fertility such as pH, content of O$_2$, nutrients, as well as factors of physical, chemical and biological soil also affect populations of soil bacteria [19], and environmental factors, especially solar radiation, which can create soil moisture is contributing factor in life that takes place in the soil, as well as the age factor also determine the population of microorganisms. Generally the population of microorganisms increases with increasing age of the plant [20].

After purification the isolates of phosphate solubilizing bacteria isolates obtained as much as 45 pure isolates. Of the 45 isolates obtained, once characterized all showed their phosphate solubilizing, characterized by a clear zone around the colony, the establishment of zoning varies from each isolate, begins to form on day 3 to day 7. and formed zoning with a diameter between 0.1-0.8 cm (Table 5), the greater the zoning indicates that the isolate has the ability to dissolve the bound phosphate into a greater phosphate solubilizing. According [21] expressed signs that some bacteria are able to dissolve
the phosphate is in the presence of clear zone at bacterial colonies area and increasing the size of bacterial colonies on media Pycovskaya, this is because the bacteria can dissolve phosphate (Ca3(PO4)2) contained in the media formulation Pycovskaya in the form of PO4 using phosphatase enzymes, thus forming a clear zone around colonies of phosphate solubilizing bacteria [22], but it is also reported by [23], which states that the formation of a clear zone as an indicator of phosphate solubilizing activity.

Test the effectiveness of breeding Phosphate solubilizing bacteria to the soybean plants showed varying results, this suggests that each breed has a match rate of the soybean crop, if the breed is suitable to host plant will generate good growth and vice versa, as reported by [24] that inoculation would significantly affect plant growth when inoculated multiply able to adapt and compete with the microbes in the soil, in addition level match between breeding and crop also affect the growth of plants [25].

The results of testing isolates inoculated against soybean plants showed that for measurements of canopy dry weight, root dry weight, number of root nodules and highest total plant dry weight in plants inoculated with 9 BTLP isolates (2) and in measurements of nodules dry weight showed that the highest value in plants inoculated with 9 BTLP (2) and 3 BTKP (3) isolates (Figure 1). Overall the parameters observed showed that isolate number 9 BTLP (2) gave the highest yield on the growth of soybean plants, this meant that the isolate had compatibility and harmony with soybean plants. Inoculation will have a significant effect on plant growth if the isolates is an effective isolates and has compatibility, and effectiveness and is able to adapt to the environment. [26].

4. Conclusion
From the results of this study concluded that the soil samples from different regions of plant roots and without plants containing phosphate solubilizing bacteria populations varies greatly. The number of bacteria ranges from 3-59 X 10⁷ CFU / g soil, and the amount of the ultimate in crop root chayote (Sechium edule). The population in the root zone is greater than those without plants, overall isolates obtained were 45 isolates, the forty-five isolates were all capable of phosphate solubilizing, zoning formation varies on day 3 to day 7. Results of the study indicate that breeding greenhouse number strain of 9 BTLP (2) (isolates of the corn plant) gives the highest on the growth of soybean plants.

Acknowledgements
The authors would like to thank the friends of the Agriculture Microbiology laboratory for their cooperation and have assisted in the implementation of this research.

References
[1] Ramkumar S and Kannapiran E 2011 Archives of Applied Science Research 3(5) 581-586
[2] Sharma S B, Sayyed R Z, Trivedi M H and Gobi T A 2013 Springer Plus 2(587) 1-14
[3] Sagervansh A, Kumari P and A N & Kumar A. 2012 International Journal of Life Science & Pharma Research 2(3) 245-255
[4] Ahemad M and Kibret M 2013 Journal of King Saud University–Science 26 1-20
[5] Girish K, Shrikant B and Sunil M 2010 Asian J Exp Biol SCI SPL 4(2) 40-44
[6] Gupta G, Parihar S S, Ahirwar N K, Snehi S K and Singh V 2015 Microbial & Biochemical Technology 7(2) 96-102
[7] Ranjan A, Mahalakshmi M R and Sridevi M 2013 International Journal of Nutrition, Pharmacology, Neurological Disease 3(1) 29-33
[8] Duangpxenga A, Phetcharata P, Chanthaphoa S and Okudab N 2013 Proceeding -Science and Engineering pp 61–66.
[9] Hajjam Y and Cherkauwi S 2017 Journal of Materials and Environmental Science 8(3) 801–808.
[10] Fitriatin B N, Yuniarti A, Turmuktini T and Ruswandri F K 2014 Eurasian J. of Soil Sci. Indonesia pp 101-107
[11] Srinivasan R, Yandigeri M S, Kashyap S, Alagawadi A 2012 Saudi Journal of Biological Sciences 19(4) 427-434
[12] Rao S W V and Sinha W K 1963 Indian. J. Agric. Sci. 33 272-278
[13] Somasegaran Somasegaran P, and Hoben HJ 1984 Methods in Legum Rhizobium Technology (Hawaii: University of Hawaii)
[14] Pelczar M J and Chan E C S. 2006. Dasar-Dasar Mikrobiologi (UI Press. Jakarta) pp 140-199
[15] Sanjotha P, Mahantesh P and Patil C S. 2011 International Journal of Microbiology Research, 3(1) 56-58
[16] Acuna J J, Jorquera M A, Martinez O A Blackburn M, Fernandez M T Marschner P, Greiner R, Mora M L 2011 Journal of Soil Science and Plant Nutrition 11(3) 4
[17] Lamptey S, Ahiabor B D K, Yeboah S and Asamoah C 2014 Journal of Experimental Biology and Agricultural Sciences 2(1) 72-77
[18] Viruel E, Erazzi E, Calsina L M, Ferrero M A, Lucca M E and Sineriz F 2014 Journal of Soil Science and Plant Nutrition 14(4) 819 – 831
[19] Keneni A, Assefa F and Prabu P C 2010 J. Agr. Sci. Tech 12 79-89
[20] Selvi K B, Paul J, Vijaya V & Saraswathi K 2017 Journal of Biology 1(1) 1-7
[21] Ilham I B G, Darmayasa, Nurjaya I G M O and Kawuri R 2014 Journal of Microbiology 62 173-181
[22] Fitriyanti D, Mubarik N R and Tjahjoleksono A 2017 Malaysian Journal of Microbiology 13(3) 147-155
[23] Pahnwar Q A, Jusop S, Naher U A, Othman R and Razi M I 2013 The Scientific World Journal. 272409 1-10
[24] Schoebitz M, Ceballos C and Ciampi L 2013 Journal of Soil Science and Plant Nutrition 13(1) 1-10
[25] Chaiharn M and Lumyong S 2011 Curr Microbiol 62 173-181
[26] Khalil S and Sohail M 2013 Trends in Life Sciences (TLS) 2(2) 10-15