Jurnal Teknologi

Full paper

Effect of Natural Zeolite (Clinoptilolite) and Urea on the Growth of *Amaranthus gangeticus*, *Clinachantus nutans* and *Capsicum annuum*

Nik Ahmad Nizam Nik Malek[a*], Niza Syafiqah Hamzah[a], Noor Hidayah Dzkulfli[a], W Mohd Madhi W Abdullah[a,b], Salehhuddin Hamdan[a]

[a]*Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[b]*Department of Chemistry, Kulliyyah of Science, International Islamic University Malaysia, 25200, Kuantan, Pahang, Malaysia*

*Corresponding author: niknizam@utm.my

Article history

Received :1 January 2014
Received in revised form :
15 March 2014
Accepted :15 April 2014

Graphical abstract

Abstract

Innovative actions are needed to improve fertilizer efficiency due to the problem of the leaching of nutrients associated with conventional fertilizer. Thus, a study was carried out to compare the effect of urea fertilizer combined with zeolite (clinoptilolite) on *Amaranthus gangeticus*, *Clinachantus nutans* and *Capsicum annuum* by comparison with the commercial fertilizer composite (IMO-Plus). IMO-Plus is a mixed fertilizer containing organic compounds, zeolites, Effective Microorganisms (EM) and N, P and K nutrients. Zeolite was found to be an important holder to retain a nitrogen (N) source in urea for the fertilization process. Without zeolite, the utilization of nitrogen (N) in urea fertilizers by *A. gangeticus*, *C. nutans* and *C. annuum* are poor. The combination of zeolite and urea fertilizers enhanced growth of these three plants in a similar fashion to IMO-Plus, since they increased the plant height, dry weight of plants, total number of leaves, width, and length of leaf significantly compared to urea without zeolite. Therefore, it is important to add zeolite as one of the major elements in the fertilizer composite as a holder for the nutrients.

Keywords: Zeolite; urea; *Amaranthus gangeticus*; *Clinachantus nutans*; *Capsicum annuum*; mixed fertilizer

Abstrak

Kaedah inovatif diperlukan untuk meningkatkan keberkesanan baja disebabkan oleh masalah larut lesap nutrien yang selalunya berkait rapat dengan baja konvensional. Oleh itu, satu kajian telah dijalankan bagi membandingkan kesan baja urea yang dicampurkan dengan zeolit (klinoptilolit) terhadap pokok *Amaranthus gangeticus, Clinachantus nutans* dan *Capsicum annuum* dengan baja komposit komersial (IMO-Plus). IMO-Plus adalah baja campuran yang mengandungi sebatian organik, zeolit, mikroorganisma efektif (EM) dan nutrien N, P, dan K. Zeolit didapati mempunyai kepentingan untuk memegang sumber nitrogen (N) dalam urea bagi proses pembajaan. Tanpa penggunaan zeolit, nitrogen yang terdapat dalam baja urea tidak dapat digunakan dengan baik oleh pokok *A. gangeticus, C. nutans* and *C. annuum*. Gabungan zeolit dan baja urea dapat meningkatkan pertumbuhan ketiga-tiga pokok ini sama seperti penggunaan IMO-Plus, di mana baja ini dapat meningkatkan ketinggian pokok, berat pokok, berat kering pokok, jumlah daun, lebar, dan kepanjangan daun yang signifikan setelah dibandingkan dengan urea tanpa kehadiran zeolit. Oleh itu, adalah penting bagi penambahan zeolit sebagai salah satu elemen utama dalam baja komposit yang berfungsi sebagai pemegang nutrien-nutrien dalam baja.

Kata kunci: Zeolit; urea; *Amaranthus gangeticus; Clinachantus nutans; Capsicum annuum*; baja campuran

1.0 INTRODUCTION

Zeolites are a family of crystalline, hydrated aluminosilicates and alkaline earth cations that have three-dimensional crystal structures such as clinoptilolite. Clinoptilolite is one of the most plentiful natural zeolites in several soil types. It also has the highest charged mineral occurring in soil and it can enhance soil Cation Exchange Capacity (CECs) [1, 2]. Zeolite can retain and slowly release cations such as NH_4^+ and K^+ because of its natural characteristics-mainly high surface area and high CEC. When chemical fertilizers such as urea are applied to soil, only a fraction reaches to the target site and the rest are subjected to process such as adsorption, degradation, run off and leaching [3]. Because of this problem, clinoptilolite is considered as it has the ability to overcome this issue thanks to its unique characteristics.

Recently, zeolite has been used in the industry and private sector, especially in the field of agriculture. It has been reported previously that the used of zeolite in the amendment of soil with manure can be a beneficial approach for decreasing chemical fertilizer application rate. It also improved the sustainability of agricultural systems because it can decrease the nutrient leaching of chemicals such as phosphate and nitrate [4]. Recently, modern agricultural practices are seeking to increase the quality of soil and improve crop yields, achieved by minimizing the loss of nutrients to the environment [5].

Nitrogen (N), a constituent of chlorophyll, protein and other molecules, is essential for plant growth, especially for leafy plants such as spinach. Therefore, its availability affects the yield and quality of agricultural and horticultural plants. As nitrogen is the nutrient most often limiting plant growth, N fertilizer is used to overcome this limitation and increase crop production [6]. Thus, the use of zeolite can improve the efficiency of urea fertilizer by controlling nitrogen leaching. The nitrogen in urea helps plants to rapidly grow, increase seed and fruit production as well as improve the quality of leaf fodder crops [7].

In this study, *Amaranthus gangeticus*, *Clinacanthus nutans* and *Capsicum annuum* were selected as model plants due to their high resistance to weather conditions, fast growth rate and most importantly their nutrient responsiveness, especially affecting the leaf growth [8, 9]. These three plants are leafy plant, thus it is appropriate to study the plant responses to urea and zeolite because nitrogen from urea plays important role in the growth of the plant-especially in the leaf [10].

Recently, the uses of zeolite in the agricultural field have also been studied on the spinach yield and quality [11]. There is also a report on the effect of zeolite on flowering of *Solanum melongena* L. and growth of *Citrus aurantiifolia Swingle* [12]. In addition, zeolite was reported to improve nitrogen, phosphorus and potassium formulated fertilizer compounds [13]. Thus, it is the aim of this research to study the effect on growth of *A. gangeticus*, *C. nutans* and *C. annuum* when using zeolite with urea compared to the use of commercial composite fertilizer containing zeolite.

■2.0 EXPERIMENTAL

2.1 Materials

Zeolite type clinoptilolite was imported from Indonesia, supplied by Provet Group of Companies Sdn. Bhd., Selangor. IMO-Plus and urea were used in this study as commercial fertilizer which was provided by the same company. The contents of IMO-Plus are zeolite, Effective Microorganisms (EM), nitrogen, phosphate, potassium, calcium, magnesium, boron and other trace elements. Propagating substrate that was used for sowing was imported from Holland (Stender).

The experiment was conducted at Pusat Kajian dan Latihan Penyelidikan Provet (PKLPP) at Desa Vista, Sepang, Selangor. The polybag size 8 × 8 cm was added with 500 g of soil which had a pH of 6. The soil's ratio was 3:2:1 (soil, rice husk and coconut fibre).

2.2 Sampling

Fresh stems of *C. nutans* were collected from Jabatan Pertanian Serdang, Selangor. The stems were cut to about12 cm long. Seeds of the *C. annuum* and *A. gangeticus* from variety of 788 Autumn were obtained from Jabatan Pertanian Serdang, Selangor.

2.3 Medium and Sowing

The propagating substrate (90 g) was filled in the polystyrene cup for sowing purposes. The stem cuttings of *C. nutans* were embedded in the propagating substrate. The cups were watered (20 ml) every day in the morning to avoid wilting. The seed of *A. gangeticus* and *C. annuum* were sowed in the 104 cell seed tray. Each tray was filled with ¾ propagating substrate and three seeds were placed into the hole on top of the substrate. The hole was then covered. The plants were watered once every day in early morning by spraying method. The temperature for seeds germination was around 25-30°C [14].

2.4 Transplant

After 2 weeks, the stem cuttings of *C. nutans* in the cups were transferred into polybags. The medium in the cup was wetted before the detachment of plant to prevent damage to the root.

Seedling transplant of *A. gangeticus* and *C. annuum* were performed on the tenth day after sowing. The seedlings were then transferred into polybags that were prepared in advance. Watering was continued once a day with 20 ml of water in the early morning as before.

2.5 Application of Fertilizers

Seven types of fertilizers were applied to the plants to compare their growth (Table 1). The fertilizers were applied on day 28 for *C. nutans* and day 31 for *A. gangeticus* and *C. annuum*. All fertilizers were applied on soil surface (top-dressing application) with three duplicates.

Table 1 Types of fertilizers applied to the plants

Fertilizer	Description
C	Control (without any fertilizer)
U2	Urea (2 g)
Z3	Zeolite (3 g)
Z3U2	Zeolite (3 g) + Urea (2 g)
Z6U2	Zeolite (6 g) + Urea (2 g)
IP3	IMO-Plus (3 g)
IP6	IMO-Plus (6 g)

2.7 Data Collection and Analysis

The height of the plants, total number of leaves, leaf width and leaf length (cm) were measured before harvested. *A. gangeticus* and *C. annuum* were harvested on day 42 while *C. nutans* on day 90. The plants were harvested and then dried in an oven at 80ºC for 24 hours to obtain dry mass. Dry mass of the plants was weighed by using analytical balance.

■3.0 RESULTS AND DISCUSSION

The growth profiles of plants (plant height, number of leaves, width and length of leaf, and dry mass) after being treated with different fertilizers are shown in Figures 1, 2 and 3 for *A. gangeticus*, *C. nutans* and *C. annuum*, respectively. The data was collected after 41 days for *A. gangeticus* and *C. annuum* and 42 days for *C. nutans*. The growth profiles (number of leaf against days) for *A. gangeticus* and *C. annuum* can be seen in Figures 4 and 5, respectively.

Figures 1, 2 and 3 show that sample Z3U2 (Zeolite (3 g) + (urea (2 g)) gave the highest growth rate for each studied plant. By means of comparison, commercial fertilizer composites (samples IP3 and IP6) (IMO-Plus)) showed quite similar results, with that of Z3U2. The application of only zeolite as fertilizer decreased the growth of *A. gangeticus* and *C. nutans*, while urea (U2) decreased the growth of *C. annuum*.

The addition of zeolite in the fertilizer (samples Z3U2, IP3 and IP6) increased the growth of plants because of the unique property of zeolite that allows it to hold nutrients, especially N element (ammonium or potassium cations), and slowly release them from the fertilizer to the plant. Because of this, all plants could obtain enough N for their growth, especially for their leaves [6]. Hence, the addition of zeolite in the urea and other fertilizers can improve the productivity and growth of the plant. As reported by Park [15], zeolite was added to the fertilizer to carry the nutrients that are essential to the plants, mainly potassium (K) and nitrogen (N), and hold them in the soil.

In addition, the mixing of zeolite with fertilizer can produce the same yield with less fertilizer applied [16]. It can decrease the volatilization process and nutrient leaching losses to the soil [14]. Since clinoptilolite has high adsorption and cation exchange capacity, it is used as a promoter for better plant growth by improving the value of fertilizers and maintains the valuable nitrogen in the soil. Li and his co-workers also reported that zeolite can also adsorb ammonium and potassium cations and slowly release them to the soil [11].

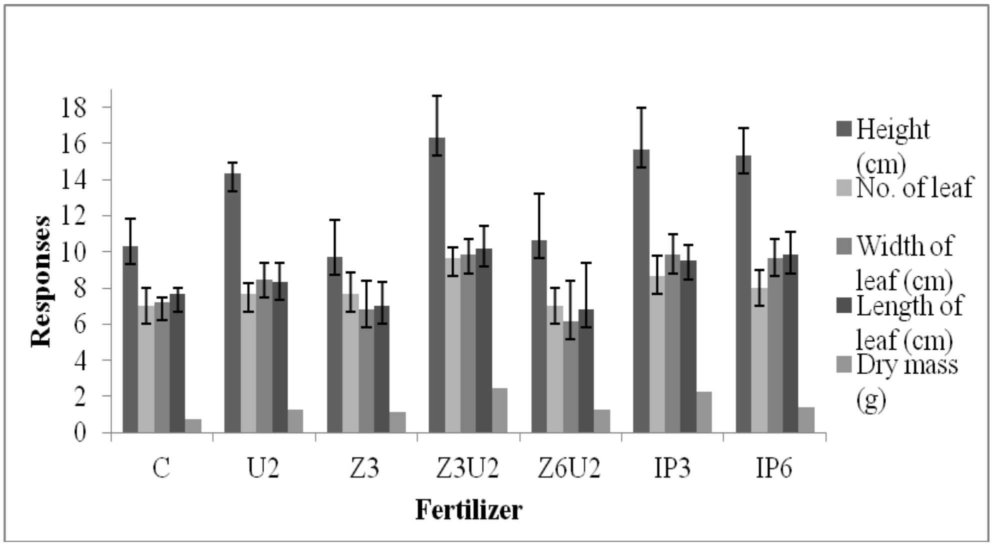

Figure 1 Effect of fertilizers on *A. gangeticus* growth

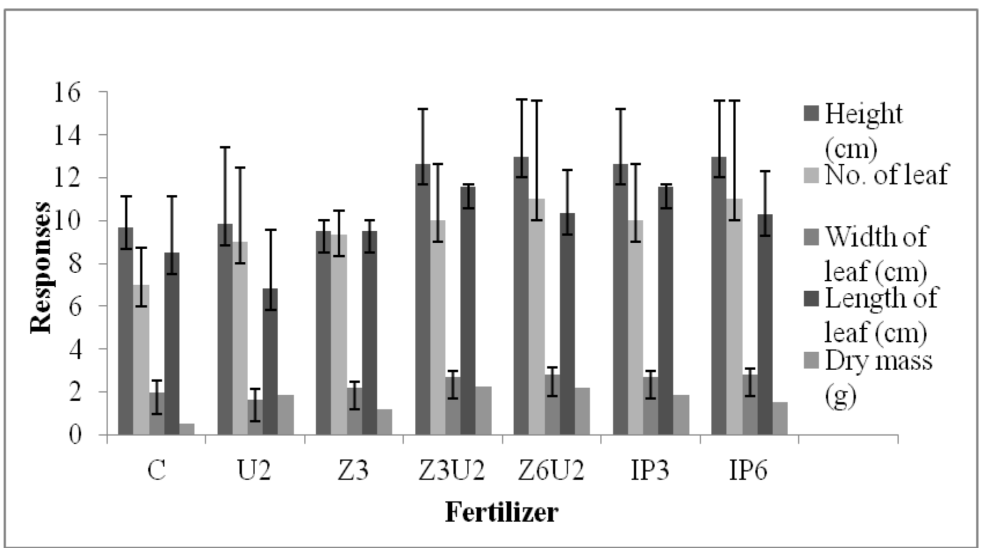

Figure 2 Effect of fertilizers on *C. nutans* growth

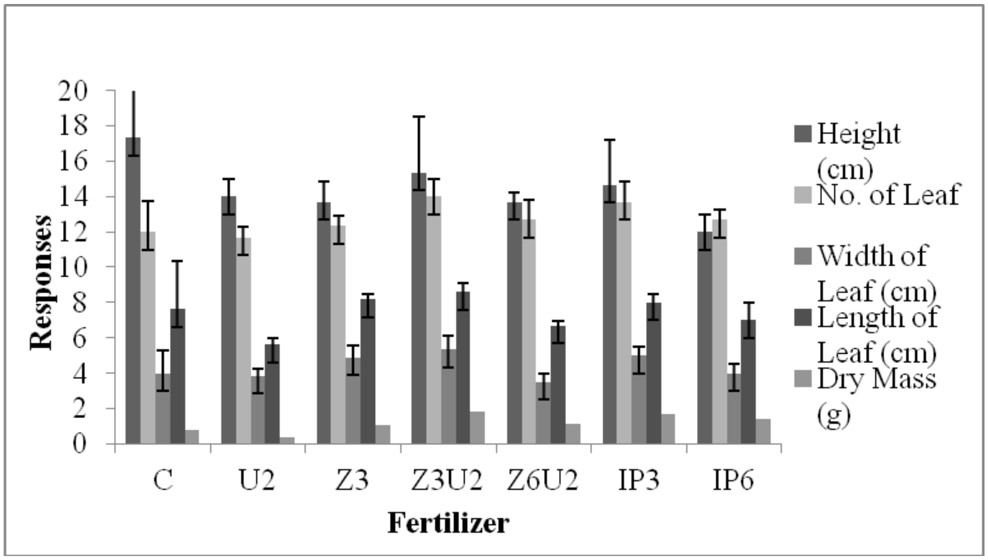

Figure 3 Effect of fertilizers on *C. annuum* growth

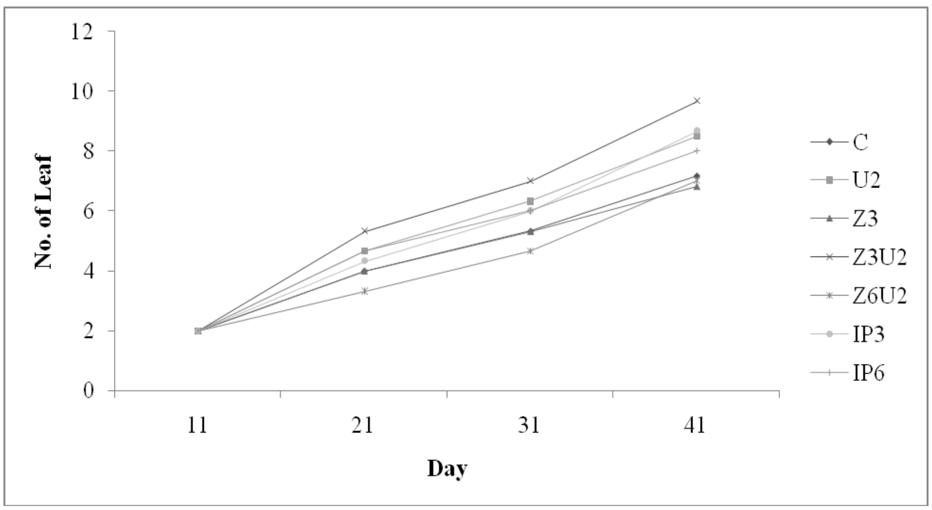

Figure 4 The growth profile of *A. gangeticus* using different fertilizers

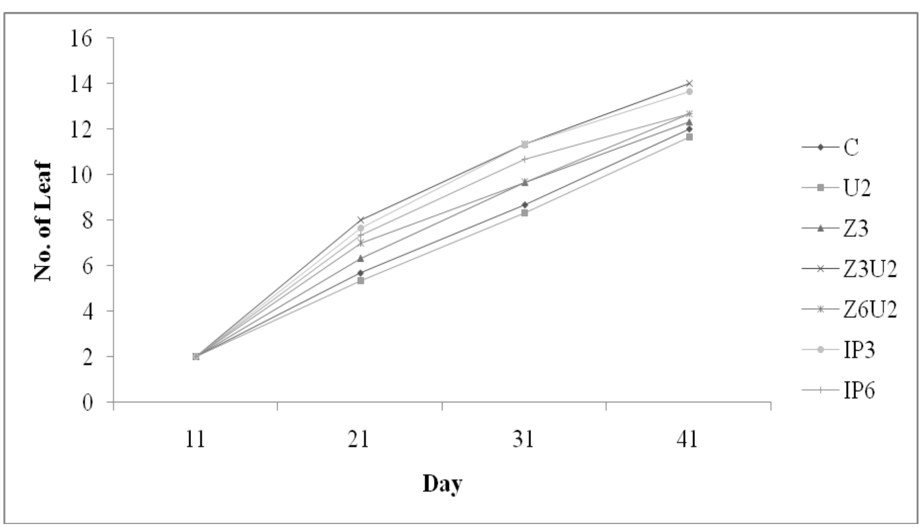

Figure 5 The growth profile of *C. annuum* using different fertilizers

On the other hand, the plants did not grow well after being applied with only zeolite (Z3) because the zeolite does not have adequate nutritional value. It does not have the nutrients needed for plant growth, such as ammonium, nitrate or phosphate.

When the plants were fertilized by urea only (U2), the average height, number of leaves, width, and length of leaves were lower. This resultis possibly due to the leaching of ammonium from urea [17].

The growth profiles (Figures 4 and 5) of the studied plants shows that the number of leaves of *A. gangeticus* and *C. annuum*were the highest when using a mixture of urea and zeolite (Z3U2). This also showed that the growth of both plants was enhanced by the presence of zeolite. As a comparison with commercial composite fertilizer, IMO-Plus also increased the plant growth, because the ingredients in IMO-Plus also containzeolite, urea and other chemical fertilizers.

The higher nitrogen uptake by plants will increase the number of leaves per plant, since nitrogen has a significant effect on the yield of plants as well as influencing their dry weight [18]. The zeolite in the fertilizer can hold and slowly release ammonium ions, thus providing the plant with N element contained within the ammonium ions.

Figures 1 to 5 show that the amount of zeolite added in urea also affected the plant growth. Decreased plant growth was observed in fertilizer containing more zeolite (Z6U2) as compared to lower amount of zeolite (Z3U2). This might be due to the higher binding capacity of the nutrient to the zeolite. Because of this, the nutrients are hardly released into the soil but with held by the zeolite. Therefore, this study also showed that the amount of zeolite added to the fertilizer could affect the plant growth. Interestingly, the lowest amount of zeolite needed is enough to increase the plant growth, consequently decreasing the cost of fertilizer.

■4.0 CONCLUSION

It can be concluded from this study that the addition of zeolite in urea or other fertilizers affects the growth and yield production of *A. gangeticus, C. nutans* and *C. annuum*. Therefore, the addition of zeolite in chemical fertilizer such as urea, NPK fertilizer or organic fertilizer is important to increase the growth of plants, especially for leafy plants that needs more N element to grow well. Hence, it is suggested that one of the elements to be added in a composite (mixed) fertilizer is natural zeolite clinoptilolite.

Acknowledgements

We are grateful to Faculty of Biosciences and Medical Engineering (FBME), UTM and Provet Group of Companies Sdn Bhd. This project was funded by research grant Sciencefund (Vot 4S038, Project No. 06-01-06-SF00994) provided by Ministry of Science, Technology and Innovation (MOSTI), Malaysia and Research Grant University (RUG) (Vot: 07J34) provided by UTM and Ministry of Higher Education, Malaysia.

References

[1] M. Rehakova, S. Čuvanová, M. Dzivak, J. Rimár, Z. Gaval'Ova. 2004. *Current Opinion in Solid State and Materials Science*. 8: 397.
[2] D. W. Ming, J. B. Dixon, 1987. *Clays and Clay Minerals*. 35: 463.
[3] D. Bhardwaj, M. Sharma, P. Sharma, R. Tomar. 2012. *Journal of Hazardous Materials*. 227: 292.
[4] M. Gholamhoseini, A. Ghalavand, A. Khodaei-Joghan, A. Dolatabadian, H. Zakikhani, E. Farmanbar. 2013. *Soil and Tillage Research*. 126: 193.
[5] D. C. Edmeades. 2003. *Nutrient Cycling in Agroecosystems*. 66: 165.
[6] M. Jalali. 2005. *Agriculture, Ecosystems and Environment*. 110: 210.
[7] A. El-Wahab, A. Mohamed. 2007. *Journal of Applied Sciences Research*. 3: 781.
[8] W. R. Sakr, M. E. Husein. 2012. *American-Eurasian Journal of Agriculture & Environmental Science*. 12: 1377.
[9] D. Preetha, P.K. Sushama, K. C. Marykutty. 2005. *Journal of Tropical Agriculture*. 43: 87.
[10] Amaranthus, 2010. Production Guideline. Department of Agriculture, forestry and Fisheries, Republic of South Africa. 6–7.
[11] Z. Li, Y. Zhang, Y. Li. 2013. *Journal of Plant Nutrition*. 36: 1496.
[12] F. M. S. Azam, B. Al Labib, D. Jabin, M. Sayeed, S Rahman, S. Islam *et al.* 2013. *American-Eurasian Journal of Sustainable Agriculture*. 7: 108.
[13] K. A. Rabai, O. H. Ahmed, S. Kasim. 2012. *African Journal of Biotechnology*. 11: 12825.
[14] N. A. Ghazi. 2008. Master Thesis, Universiti Teknologi Malaysia.
[15] M. Park, J. S. Kim, C. L. Choi, J. Kim, N. H. Heo, S. Komarneni, J. Choi. 2005. *Journal of Controlled Release*. 106: 44.
[16] F. Daryaei, A. Ghalavand, A. Sorooshzadeh, M. R. Chaichian, M. Aqaalikhani. 2011. *International Research Journal of Applied and Basic Sciences*. 2: 20.
[17] A. M. Dave, M. H. Mehta, T. M. Aminabhavi, A. R. Kulkarni, K. S. Soppimath. 1999. *Polymer-Plastics Technology and Engineering*. 38: 675.
[18] S. Nasreen, M. M. Haque, M. A. Hossain, A. T. M. Farid. 2007. *Bangladesh Journal of Agricultural Research*. 32: 413.