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Effect of Polyvinyl Alcohol/Chitosan Hydrogel Loaded with NPK Compound Fertilizer on *Capsicum sp.* Growth and Fruiting Yield Analysis

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Abstract
This paper reported on the reinforcement of superabsorbent (SA) fertilizer based from polyvinyl alcohol (PVA) using chitosan via superficial freeze-thawing method. The obtained SAP beads are well developed with excellent mechanical properties and high NPK compound fertilizer loading at 6 wt% chitosan loading. The effect of PVA/chitosan hydrogel on plant growth and fruiting yield was observed using Capsium sp.by comparing with conventional fertilizer. The studies showed plant samples with PVA/chitosan hydrogel growth exceptionally in term of its number of fruits(43±1), total mass fruit yield (1654±1.3g), fresh and dry weight of plant (139.5±1.2%), leaf number (130.6±0.2%) and width (19.8±0.6%) as well as chlorophyll content (0.036659) compared to conventional fertilizer method. Overall, these give good indication of the modified SAP fertilizer as a new technology to be used in future agriculture.

Keywords: hydrogel, superabsorbent fertilizer, agriculture, plant growth, fruiting yield

Introduction

Capsicum sp. was consumed in a wide range, as fresh produce and products for ingredients and medicine. Therefore, as the demand for fresh chili fruits and products increases both in domestic and foreign trades, there is a need to increase the crop production (Meghavansi *et al.*, 2010). Thus, attempts to increase fruit and seed yield have been introduced such as variety improvement, cultural practice and application of some chemicals to induce growth and development. However, the large problem faced in agriculture recently is the loss of nutrient elements. It causes the insufficient of plant nutrients, increases process cost and pollutes the environment (Dbe, 2011). With the use of controlled-released systems, nutrients are released at a slower rate throughout the seasons, plants are able to take up most of the nutrients without waste by leaching (Kanjana, 2017; Nayan *et al.*, 2018).

Superabsorbent polymers (SAP), a new functional polymer material, can absorb a large amount of water, swell to many times their original size and weight and the water is hardly removed even under pressure, and so it has been widely used in agriculture as controlled-release fertilizer (Liu *et al.*, 2006). Hydrogel is a loosely cross-linked three dimensional networks of hydrophilic monomer with the ability to absorb great amount of water. Hence, the combination of hydrogel and fertilizer has become one of the promising materials to overcome the shortcomings of conventional fertilizer by greatly improving the nutrition of plants, decreasing fertilizer loss rate, alleviating environmental impact from water-soluble fertilizer, supplying nutrients sustainably and lowering frequency of irrigation (Guo *et al.*, 2005).

In our previous study, showed that the potential of polyvinyl alcohol (PVA) hydrogel reinforced with chitosan as SAP hydrogel fertilizer using freeze-thawing method (Nayan *et al.*, 2018). The SAP hydrogel have excellent crystal like structure distribution swelling properties which suitable for controlled release fertilzer application. Therefore, in this study the SAP hydrogel was analyzed to determine its effect on Capsicum sp. growth in term of number and total weight of fruits produce, fresh and dry weight of plant, physical characteristic of leaf and chlorophyl content.

Materials and methods

Preparation of PVA/Chitosan hydrogel loaded with fertilizer compound

The PVA/6%Chi hydrogel loaded with NPK compound (SAP hydrogel) was prepared using freeze-thawing method as describe in previous study (Nayan *et al.*, 2018).

Preparation of Capsicum sp. for growth analysis

The growth analysis of Capsicum sp. were done using purcahsed 20 plants per plot at age 4 weeks and re-planted in 10x12 inches polybags. Each plots were planted with SAP hydrogel, chemical fertilizer (CF), organic fertilizer (OF) and without any fertilizer as control. The watering was done at alternate day for each plot and monitored within 1 week interval period. The growth analysis were measured at 1, 2, 3 and 4 week's interval period.

Total yield and the number of fruits

To measure total yield of each of the plant after fruits harvest, by a digital scale, the weights of fruits were registered in consecutive harvest. To calculate the number of fruits in the plant, the total number of harvested fruits of each plant was recorded after weighing session.

Fresh and dry weight of plant, number of leafs and width of meatured leaves

The measurements of dry and fresh weight of plants were done at the end of harvest. The fresh weight was recorded after the complete cut of plants from the soil surface by digital scale. To measure fresh weight of the root, it was weighed after washing. The shoots and roots were put in the oven at 70 ºC for 24 h and after weighing, their dry weight were recorded. Plant width of matured leaves were measured by ruler, respectively. For width of leaves measurement, few matured leaves from each pots were measured and the average were obtained.

Photosynthetic pigments

Photosynthetic pigments content was determined by taking fresh leaf samples (0.1 g) from young and fully developed leaves. The samples were homogenized with 5ml of acetone (80% v/v) using pestle and mortar and centrifuged at 3,000 rpm. The absorbance was measured with a UV/visible spectrophotometer at 663 and 645nm and chlorophyll contents were calculated using the equations proposed by Strain and Svec (1966).

Results and discussion

Total yield and number of fruits

The fruits produced were harvested and counted for 4 weeks and weighted at 2nd and 4th weeks of experiment duration. Figure 1 shows the numbers of chilly fruits produced using different types of fertlizer. The samples with PVA/6%Chi NPK hydrogel produced highest number of fruits followed by chemical fertilizer, organic fertilizer and control sample. It was expected the control produced low number of fruits due to lack of nutrients and minerals for plant growth. Besides, the total yield is higher at SAP hydrogel sample compared to chemical, organic and control fertilizer as indicated in Figure 2. This contributes by the chitosan monomer in the SAP hydrogel that act as plant growth promoter (PGP) that important in enhancing plants growth as well as has elicitor effect against plant disease (Karanatsidis and Berova, 2009).

On the other hand, other study also reported that the application of chitosan in agricultural system help to control the release of NPK due to its hydrophobicity charactheristic (Kuo, 2015). Control release strategy do help to keep consistance nutrrient supply for plant growth unlike burst release fertilizer such as chemical/organic fertilizer that tend to leach out before plants able to absorb as food supply. Appart from that, the application of to much chemical/organic fertilizer could lead to 'burn' foliage and damage to the plants due to excessive nutrient at soil that lead to toxic condition (Jamir *et al.*, 2017).

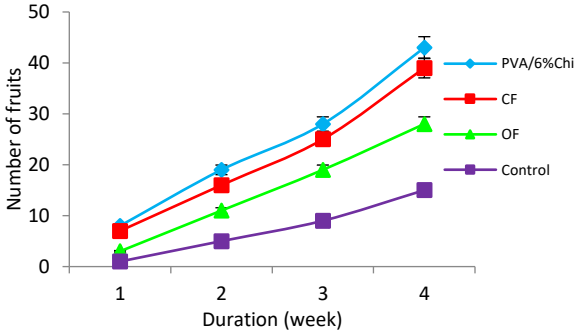
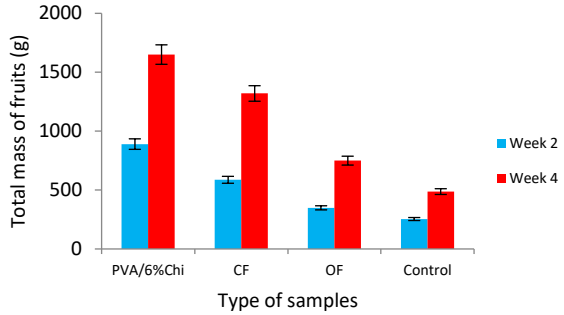


Figure 1: Total production of Capsicum sp. fruits by using different types of fertilizer



.Figure 2: Total mass of Capsicum sp. fruit yield using different types of fertilizer

Fresh and dry weight of Capsicum sp. plant

Figure 3 showed the percentage increase on fresh and dry weight of chilly plants from week 1 until 4. Plants with chemical fertilizer result in the highest fresh weight and dry weight was due to its minerals component content was formulate to give quick boost for the plants growth (Jamir *et al.*, 2017). Unlike the longer time-period taken by organic fertilizer to work on the growth of the plants, chemical fertilizer work in a hastened manner and work their appropriate actions on the plants in the required time-frame. However, SAP hydrogel have better potential on future agricultural application due its controlled release mechanism that more economical advantages. Although it might work slower but it will gave everlasting impact on the soil texture, improves the water holding capacity of the soil, regains its fertility and prevents soil erosion which help better plant growth (Zayed *et al.*, 2013).

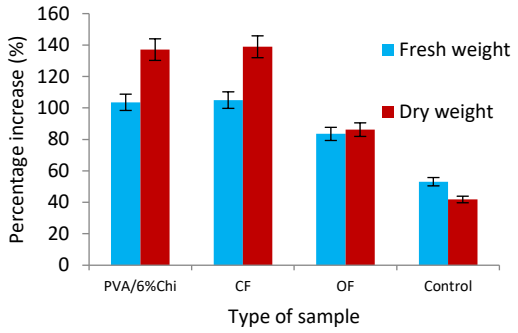


Figure 3: Average percentage increase of fresh and dry weight of Capscum sp.

Number and width of matured leaves

The number of leaves increased almost 130.6±0.2% for SAP hydrogel compared chemical fertilizer (124.5±0.4%), organic fertilizer (59.5±0.3%) and control (31.13±0.7%) respectively as showed in Figure 4. Although chemical fertilizer gave a quick boost in early stage, due to uncontrolled release resulting for lower nutrient in soil after certain period. This will reduced soil texture and soil's long-term fertility condition for plant growth (Jamir *et al.*, 2017). The same trend also showed by width of leaves in Figure 5, where the control showed lowest increase of width leaves and the highest was SAP hydrogel fertilizer. Previous study, showed that SAP hydrogel fertilizer have tendency to hold more water in soil that allowed control release of nutrient for plant uptake. This advantages will help to keep the moisture of the soil and act as nutrient reservoir for the soil plant system that helps in utilizing water and nutrient uptake effectively (Nayan *et al.*, 2018).

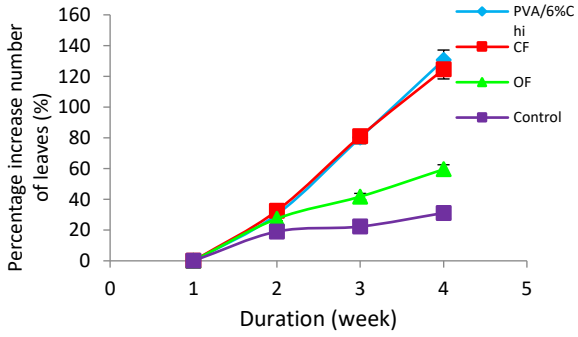


Figure 4: Percentage number of Capsicum sp. leaves

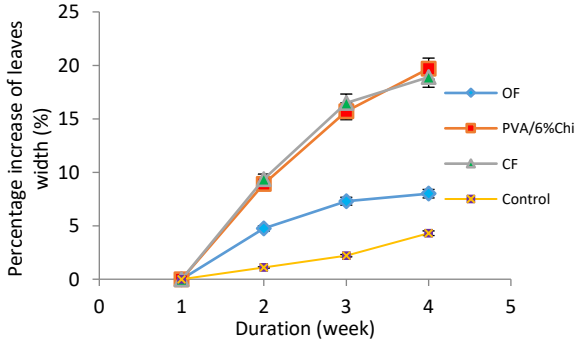


Figure 5: Width leaves trend for 4 weeks

Photosynthetic pigments

Chlorophylls are greenish pigments which contain a porphyrin ring where surrounded free moving electron that make the ring potentially to gain or lose electrons easily, and thus also able to provide energized electrons to other molecules. This is the fundamental process by which chlorophyll "captures" the energy of sunlight or known as photosynthesis that will manufacture sugars as food for plant growth (Humphrey, 2004; Baker, 2008). Figure 5 showed the chlorophyl content of Capsicum *sp.* leaves in different fertilizer, which overall indicates that the SAP hydrogel not only improve physical characteristic of the plant but at the same time enhanced the leaf chlorophyll content. This also give early indication that the plant have consumed adequate amount of N mineral as N is a component of the chlorophyl where the deficiency of this element will be reflected as chlorosis in leaf (Dutta et al., 2004; Ayala-Silva and Beyl, 2005; Soetan et al., 2010). Therefore, this give indirect good indication on food production by the plant to ensure continous growth.

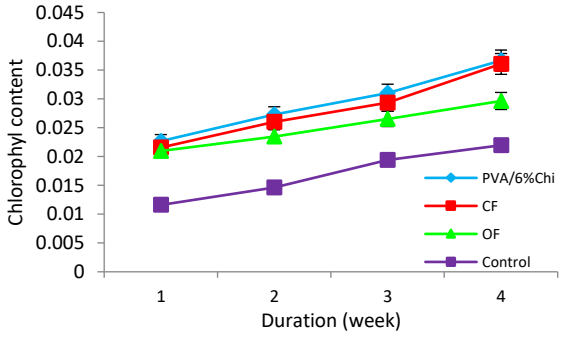


Figure 6: Chlorophyll content of Capsicum sp. leaves

Conclusions

PVA/6%Chi hydrogel loaded with NPK (SAP hydrogel) shown highest results for plant growth parameters compared to chemical fertilizer, organic fertilizer and control sample. The application of SAP hydrogel showed positive results in term of fruit number and total weight, fresh and dry mass of plant, number and width of leaf as well as the chlorophyll content. Although through works have been done, further investigation is needed to study the kinetic mechanism of the fertilizer, the effect of SAP hydrogel onto plant tissue and effect on *Capsicum sp.* mass production.

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