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# EFFECTS OF INDIGENOUS MICROORGANISM AND SYSTEM OF RICE INTENSIFICATION FORMULATION ON GROWTH, PHYSIOLOGY, NUTRIENT UPTAKE AND RICE YIELD

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*Keywords:* Rice yield, Indigenous, Microorganism, Rice Intensification (SRI)

**Abstract**

The application of indigenous microorganism (IMO) and system of rice intensification (SRI) *Anak* formulation on growth and nutrient uptake of rice variety MR219 at nursery level was carried out. Results showed the highest plant height, leaf area, fresh and dry weight of rice variety MR219 when treated with IMO and SRI *Anak* formulation. Accumulation of N, P and K content in leaf and root tissue is much affected by spraying with SRI formulation. IMO had less influence in increasing the nutrient content in leaf and root tissue at nursery level. IMO and SRI formulation is potentially to be used as bio-fertilizer and bio-regulator to reduce environmental problems.

## Introduction

Rice (*Oryza sativa* L.) is the staple food for people in many countries around the world. World production of rice was accounted for 494.4 million tonnes in the year 2014 (FAO 2015).The demand of rice in the market is always rising up. Intensive rice cultivation has been introduced to increase rice production and meet the country's need for food security. However, the system of intensive rice cultivation will bring to the negative impact to the environment (Sampanpanish 2012).

Traditional rice farming is the highest consumer of water among all crops and uses about 80% of the total irrigated fresh water resources in Asia. However, fresh irrigation water becomes one of the limiting factor due to competition between urban and industrial sector (Bouman and Tuong 2001).

People are demanding a safer food due to the increasing price of chemical fertilizer and environmental pollution. Farmers and researchers always find safer approach to maintain soil fertility by using natural resources such as agriculture by-product. System of rice intensification (SRI) is considered to be as a smart agro-ecological methodology base on organically grown agriculture product and works by changing the management of plants, soil, water and nutrients (Gopalakrishnan and Kumar 2013). The aim of this system is to increase the productivity of rice by minimizing water usage and to solve the water scarcity problem. Recently, the application of SRI technology has also been applied to other vegetable crop.

Utilization of compost, indigenous microorganism (IMO), enzymes from technology farming, arbuscular mycorrhizal fungi (AMF), and effective microbes have been used as soil enhancer (Aini 2006). The role of microorganism is beneficially used to increase the amount of macro- and micronutrient as they live naturally in the soil and have mutual interaction with the plant.

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Therefore, the aims of the present study were: (i) to investigate the effect of IMO and SRI formulation on growth and nutrient uptake of rice variety MR219, (ii) to determine the influence of SRI application on growth performance and (iii) physiology changes of rice variety MR219 grown under field condition.

## Material and Methods

The experiment was carried out at nursery level to investigate the effects of IMO and SRI formulation on vegetative growth, physiology and nutrient uptake of rice (*Oryza sative* L.). The experiment was done for five weeks between middle of June and July, 2013 at Rice Research Institute, Field 10, Universiti Putra Malaysia (UPM). New emergences of rice seedling were treated with (i) IMO and SRI formulation (+IMO, +SRI), (ii) IMO and without SRI formulation (+IMO, –SRI), (iii) without IMO and with SRI formulation (–IMO, +SRI) and (iv) without IMO and SRI formulation (–IMO, –SRI). All the treatments were referred as T1, T2, T3 and T4, respectively. The experiment was carried out in randomized complete block design (RCBD) with four replications including day after planting as a factor. Plant height, leaf area, plant fresh and dry weight as well as nutrient content in leaf and root tissue were determined every week interval after each treatment.

Clay type soil was used as the planting medium. The soil was not sterilized to stimulate true conditions like in the field. About 500 g of soil was taken into tray and water was added at saturated point and mixed very well with prepared IMO formulations and left for one month. After one month old rice seedlings were transplanted into soil of the tray. The seed of rice plant (*Oryza sativa* L.) of the variety MR219 were obtained from commercial farmer in Tanjung Karang, Selangor. The pre-germinated seeds were then shown in the tray. There were 20 seeds per tray and the same planting distance was used among seeds.

IMO is a natural product that can be prepared from surrounding home area such as cooked rice and brown sugars. Milled rice was used because it is high in carbohydrate content and can attract many beneficial microorganisms. The cooked rice was then put into container and covered with paper and tied with rubber band. The covered container was then buried in the soil just enough the container cannot be seen. It must bury under bamboo groove or a place with thick decomposing plant residues. A plastic cover was placed at the buried place to avoid entering of water and soil. After 5 days, IMO is formed. It is called IMO stage 1 (Samin 2011). For rice farming, the first IMO must extend further and the end product is called IMO stage 2. Then the IMO stage 1 was mixed with brown sugar with ratio 1 : 1. The mixture is kept in a container and mixed thoroughly. Paper and rubber band are used to cover the container and kept it in the shaded area. After five days, IMO stage 2 is produced. IMO contains a lot of beneficial microbes. It can be used as a decomposer material for making compost. It is also sprayed to rice straw before the rice field undergoes tilling process. It promotes the decomposition of rice straw in the soil. IMO stage 2 contained *Bacillus subtilis* which makes the decomposition process faster. Usually, rice straw takes 3 weeks for total decomposition (Noorazimah 2013). For this experiment IMO stage 2 was obtained from commercial producer in Kuala Selangor, Selangor. Before it can be used, it must be mixed with fermented plant juice (FPJ). FPJ was made by mixing the sliced water spinach and brown sugar at the ratio of 1 : 1 in a small container. The container was kept for six days to allow fermentation process. After six days, FPJ was mixed with IMO stage 2 and applied to the soil one month before planting.

SRI formulation was obtained from commercial producer in Kuala Selangor, Selangor. The SRI formulation was sprayed to the rice plant during 7, 15 and 23 days after planting (DAP). The irrigation was done manually, once a day in every morning. Water level was kept at saturated

point or 1 cm above soil. Urea, muriate of potash (MOP) and triple-superphosphate (TSP) were used for N, P and K source of fertilizer. Application of urea, MOP and TSP were applied at the rate of 36, 30 and 40 kg/ha, respectively. Weeding was done manually as and when necessary.

Plant height, leaf area, plant fresh and dry weight, plant tissue analysis were measured. The height was taken once in each interval of 7 days starting from 14 DAP. Leaf area was determined using leaf area meter (LI-3100, USA). Plant biomass was measured every 7 days interval. The analyses of plant tissues were made to determine the nutrient status of N, P and K in both leaf and root tissues.

The experimental data were subjected to ANOVA using SAS release 9.3 (SAS Institute Inc., Cary, NC, USA). Fisher's least significant differences (LSD) were calculated following a significant ($p \leq 0.05$) F-test. All the assumptions of ANOVA were checked to ensure validity of statistical analysis.

## Results and Discussion

There was significant increase in plant height with increasing DAP of rice treated with IMO and SRI *Anak* formulation (Fig. 1). The growth of rice plant in $T_1$ is boosted with application of SRI *Anak* formulation. Higher plant height of paddy treated with IMO and SRI *Anak* formulation indicated that application of organic enhancer (IMO and SRI *Anak* formulation) will increase the soil fertility. The similar result was also reported by Samin (2011) who reported that the plant and microorganism live symbiotically in natural environment. Beneficial microorganisms such as IMO and SRI *Anak* formulation produce nutrients, hormones and antibiotics in small quantities and plant absorb it. Certain inorganic fertilizers allow the plant to skip this process and plant has to absorb the nutrient in larger quantities. This is not a good process as it can burn to the roots system which may cause the death of the seedling or it will undergo slow growth in later stage.

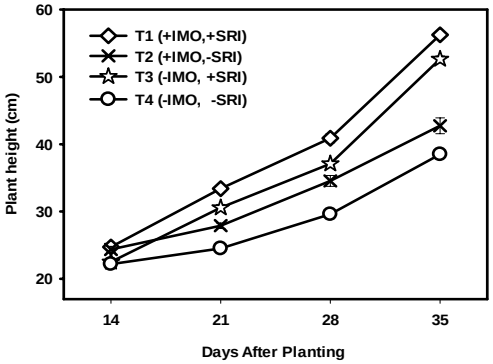


Fig. 1. Plant height of paddy variety MR219 as influenced by IMO and SRI *Anak* formulation.

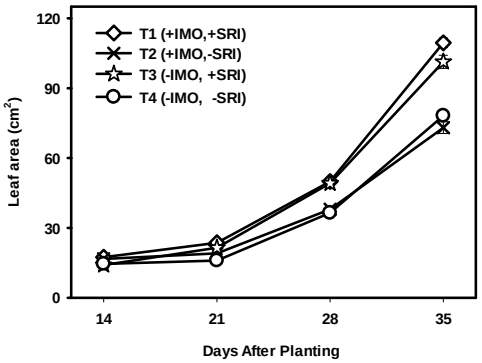


Fig. 2. Leaf area of paddy variety R219 as influenced by IMO and SRI *Anak* formulation.

The result obtained from ANOVA table showed there were significant difference on leaf area among all the treatments on 14 and 21 DAP (Fig. 2). Increases in leaf area during 21 and 35 DAP might be due to higher content of N in formulation of SRI *Anak* (unpublished data). Synergism from foliar spray of SRI *Anak* formulation as well as interaction between application of IMO and available nutrient in the media help the rice leaf area and healthier. These contributed to the increase in photosynthesis rate. Result showed that the application of IMO and SRI *Anak* formulation is potentially contributed to better rice yield in the actual plantation in the field. In the

present study revealed that plants grown in SRI with application of organic formulation has more erect leaves which avoided mutual shading of leaves as compared to best management practices (Gopalakrishnan and Kumar 2013).

Fig. 3 showed the effect of IMO application and SRI *Anak* formulation in the planting media on fresh leaves weight of rice variety MR219. Increase in fresh leaf weight is probably due to enhancement in N content as a result of application of SRI *Anak* formulation. Nitrogen plays a key role in triggering leaf initiation, increasing chlorophyll content and enhancing photosynthesis process which lead to better vegetative growth.

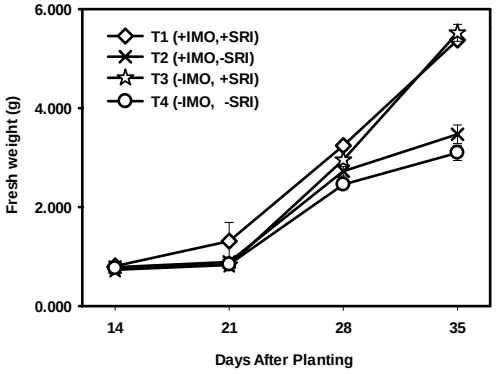


Fig 3. Leaves fresh weight of paddy variety MR219 as influenced by IMO and SRI *Anak* formulation (T).

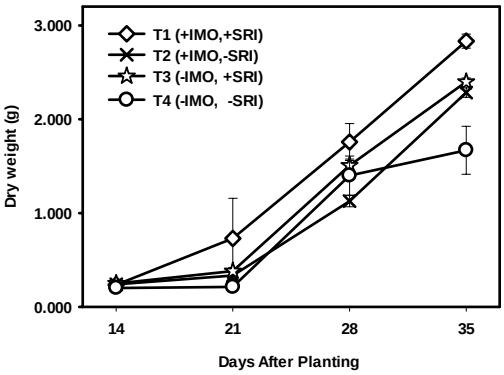


Fig. 4. Leaves dry weight of paddy variety MR219 as influenced by IMO and SRI *Anak* formulation (T).

Fig. 4 shows the effect of IMO application and SRI *Anak* formulation on fresh leaves weight of rice variety MR219. Results from the study show that T1 gave higher value of fresh leaves weight than other treatments, however based on Tukey grouping comparison, all treatments do not have any significant difference among them on 14, 21 and 28 DAP.

Fig. 5 shows the effect of IMO and SRI *Anak* formulation on N, P and K content in leaf tissue of rice variety MR219 (Fig. 5a-c). On 21 DAP, content of N and P in leaf tissue showed significant difference. Rice treated with T1 has the highest nutrient uptake of N and P. Meanwhile K content in rice does not show any significant difference (Fig. 5c). Result showed that N content had significantly difference among the treatment on 28 DAP. It showed that on 28 DAP, T1 had 4.41% higher N content in leaf tissue than the control (T4) (Fig. 5a). Rice treated with T1 showed significantly higher P content in leaf tissue than other treatments on 28 DAP (Fig. 5b). Similar trend was found when rice was treated with T2 and the leaf tissue exhibited higher K content than other treatments on 28 DAP (Fig. 5c).

There was significantly different content of N and P in leaf tissue for all the treatments on 35 DAP. T1 exhibit the highest N and P content which are 6.58 and 0.21%, respectively (Fig. 5a, b). Content of K did not show any significant difference among all the treatments on 35 DAP (Fig. 5c). Mean of N and K content in leaf tissue from plant treated with T3 exhibited 5.4 and 1.81% higher content increment throughout 35 DAP, respectively (Fig. 5a, c). Meanwhile, T1 showed 2.25% increments of P content in leaf tissue on 35 DAP and it was 1.44-fold higher than the control (Fig. 5b). Previous study showed that SRI organic formulation contributes to greater nutrient uptake by plant tissue than non-SRI treated plant. The findings confirm that nutrient

uptake considerably enhanced by management system and used organic formulation (Barison and Uphoff 2010).

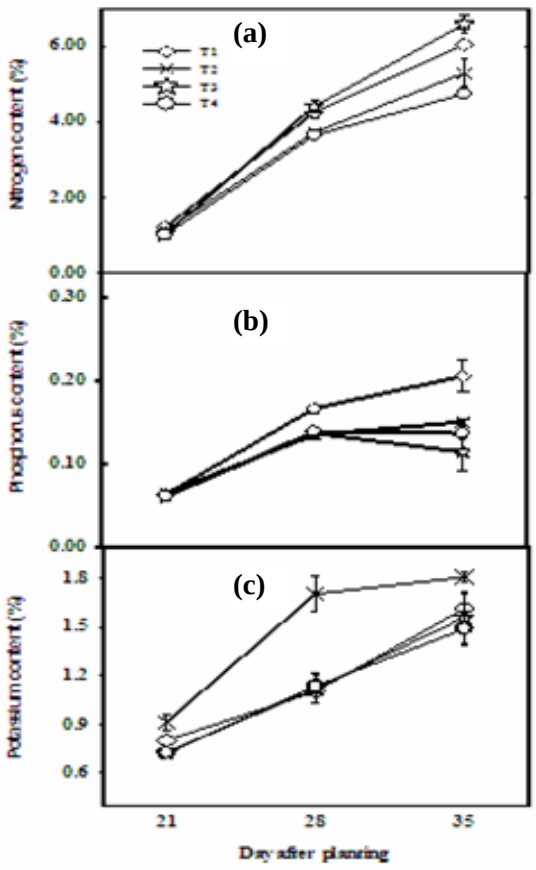


Fig. 5. Concentration of (a) N, (b) P and (c) K in leaf tissue of rice variety MR219 as influenced by IMO and SRI *Anak* formulation. Vertical bar represents SE of means.

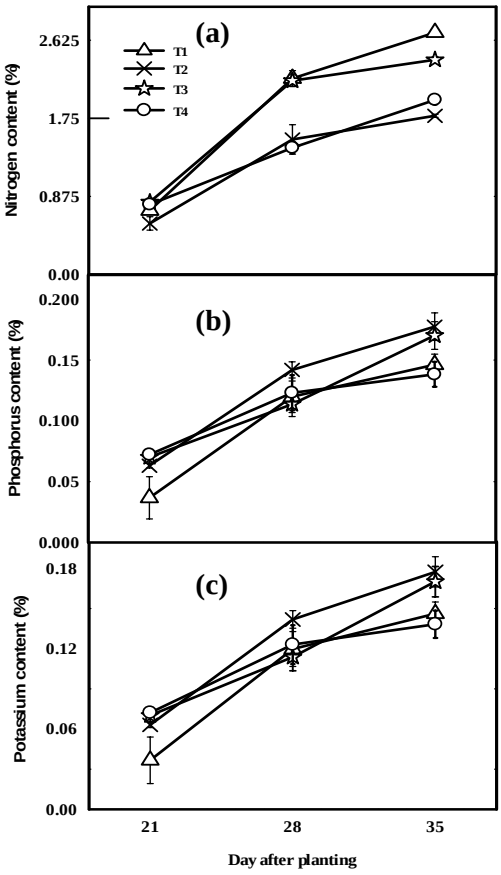


Fig. 6. Concentration of (a) N, (b) P and (c) K in root tissue of rice variety MR219 as influenced by IMO and SRI *Anak* formulation.

Fig. 6 showed the effect of IMO and SRI *Anak* formulation on N, P and K content in root tissue of rice variety MR219. Rice either treated with or without IMO and SRI *Anak* formulation exhibited increasing trend of N, P and K content in root tissue over 35 DAP (Fig. 6a-c). On 21 DAP, rice treated with T3 exhibit the highest N content which is 0.8% in root tissue than other treatments (Fig. 6a). Results also showed that plant treated with SRI *Anak* formulation and IMO did not show any significant different in P and K content in root tissue of rice variety MR219 as compared to control on 21 DAP. Content of P and K was in the range of 0.04 - 0.07% and 0.62-0.72%, respectively (Fig. 6b, c). T1 and T3 exhibited significantly higher N content in root tissue of T2 and T4 on 28 DAP (Fig. 6a). Rice treated with T1, T2 and T3 resulted in significantly higher K content in root tissue than control (T4) on 28 DAP (Fig. 6c).

Rice treated with IMO and SRI *Anak* formulation (T1) exhibited the highest increment rate of N, P and K content by 2.78, 2.89 and 0.5% in root tissue than control and other treatment from 21 to 35 DAP (Fig. 6a-c). There were significant difference among all treatments either with or without IMO and SRI *Anak* formulation on the content of N in root tissue on 35 DAP (Fig. 6a). P content in root tissue of paddy rice treated with T1 exhibit 2.71% higher than control on 35 DAP (Fig. 6b). Result on K content in root tissue was found significantly higher in rice treated with SRI *Anak* formulation without IMO application (T3) than control on 35 DAP (Fig. 6c).

In conclusion, the application of IMO and spraying with SRI formulation increased plant growth, physiology and nutrient uptake of rice variety MR219. IMO and SRI formulation is potentially to be used as bio-fertilizer and bio-regulator also. It could be an approach to reduce environmental pollution due to excessive use of chemical fertilizer in order to produce a safer staple food.

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