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Improved Growth and Yield Formation of Red Rice under Aerobic Irrigation System and Intercropping with Peanuts

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Abstract: *This study was aimed to examine the effect of different cultivation techniques on growth and yield components of an amphibious promising line of red rice by conducting a field experiment on ricefield in Beleke village of West Lombok (Indonesia) from May to August 2018. The experiment was arranged according to Split Plot Design with two factors and three blocks. The main plot factor was cultivation technique (T) with three treatments (T1= conventional; T2= aerobic rice systems (ARS) on raised-beds; T3= ARS intercropped with peanuts), and the sub-plot factor was rice row patterns (P) with three treatments (P1= normal or single-row; P2= double-row; P3= triple-row). In the intercropping raised-beds, peanut seeds were relay-planted between single-, double-, or triple-row of rice at two weeks after seeding rice. Results indicated that red rice plants grown under aerobic irrigation systems on raised-beds, especially those intercropped with peanuts, showed higher growth performance and yield formation potentials than those on the conventional technique, especially in terms of panicle and filled grain number per clump, indicating higher potentials of yield formation under aerobic or aerobic systems additive-intercropped with peanut. Patterns of rice rows also showed significant effect on several yield components, but there was an interaction effect on filled grain number per clump, which was lowest in single-row in the conventional or aerobic rice but it was not significantly different between patterns of rice rows under aerobic rice additively intercropped with peanut, indicating positive effects of relay planting of peanuts between rows of red rice.*

Keywords: *rice systems; conventional rice; rice row patterns; raised-beds; additive series; peanut*

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I. Introduction

In Indonesia, and most growing rice areas in the world, rice is generally grown under flooded system, which is called conventional technique of growing rice. Thus the needs for irrigation water for rice production are very high. In some areas with abundant irrigation water availability, the farmers even let water flow continuously between paddocks. With the increasing rate of conversion of land use from paddy fields to non-agricultural uses, especially in and around city areas, the rice production areas will be getting narrower. These conditions coupled with the continuing increase in population density will make the ratio of rice production and population eating rice will be decreasing unless extension of production areas to non-irrigated areas is made. However, in an immediate timeline, import is normally the easiest way in achieving food sufficiency. Indonesia, for example, still imports rice. From 2000 to 2018, Indonesia's rice imports have reached 15.89 million tons, including 500,000 tons in 2018 (Fauzi, 16-01-2018).

To reduce imports on rice, domestic production must be increased. One way to increase production is to increase productivity in addition to expanding the planting area onto less productive or less irrigated or dryland areas. To increase productivity to above the current levels, there should be a breakthrough in production technology by researching for new innovations or better production technologies that enable rice crops to produce more rice with less input of water and commercial fertilizers. Applying conventional techniques of rice cultivation, in which rice is grown under inundated system that is commonly practiced by the farmers, is no longer suitable for increasing or maintaining reasonably high rice productivity in the long-term. With the conventional techniques of rice cultivation it has been proven in Madagascar that rice productivity is constantly low, and there is even a tendency to decline from year to year if intensive inorganic external inputs are not used, and conventional lowland rice systems are highly dependent on the application of artificial fertilizers to maintain certain productivity levels. However, with a non-conventional technique such as the SRI (System of Rice Intensification) technique, in which the growers apply intermittent irrigation during the vegetative phase and thin flooding in the reproductive phase and the use of compost, it has been proven in Madagascar that rice productivity can be increased significantly. It was reported that a farmer after applying the SRI techniques organically for 6 years, obtained 2.74 tons of rice grain yield on a ricefield of only 0.13 ha (equivalent to 21 t/ha), but with the conventional techniques in the plots next to it, the average rice yield was only 2.6 t/ha (Uphoff, 2002, 2003).

In addition to the SRI technique, later aerobic rice cultivation techniques have begun to be developed. In aerobic rice systems (ARS), rice is cultivated without prior puddling the soil and without inundation (Bouman, 2001; Prasad, 2011). Rice cultivation under irrigated aerobic systems can be done using sprinkler irrigation systems or raised-bed systems by applying irrigation water through the furrows (Bouman, 2001). In pot culture, rice plants, grown in aerobic system through application sub-irrigation systems, produced significantly higher number of tillers and panicles per clump compared with those under conventional systems (Dulur *et al*., 2015). Since the rice plants are not flooded in the aerobic rice systems, then rice plants can be grown in intercropping with legume crops. Dulur *et al*. (2016) also reported that red rice grown together with soybean in pot culture under aerobic system also produced significantly higher panicles and grain yield per clump compared with those grown under the flooded system or the conventional technique. Under raised-bed systems, Farida *et al*. (2016) also reported that additive intercropping by inserting a row of peanut plants between double or triple-row of red rice plants at two or three weeks after planting rice, can significantly increase growth rate, number of tillers, and number of panicles of the red rice. Because the application of an aerobic rice system to permanent raised-beds can be carried out without flooding, there is also a great opportunity to intercrop rice with legume crops, which have the ability to fix atmospheric nitrogen to increase N availability to both crops. In addition, legume plants are also generally very responsive to associations with arbuscular mycorrhizal fungi (AMF), which can help plants to take up more nutrients, especially P, which is needed to increase the rate of N fixation by legume plants (Thompson, 1991; Vejsadová *et al*., 1992; Anderson and Ingram, 1993). In an intercropping system, there is also a great opportunity for the transfer of nutrients between intercropped plants through the hyphal bridge, namely hyphae of AMF infecting adjacent roots of two or more intercropped plants (Hamel and Smith, 1991; Chu *et al*., 2004; Smith and Read, 2008).

This research was aimed to examine the effects of different rice cultivation techniques between conventional and aerobic irrigation system and intercropping with peanut under different patterns of rice rows, on growth performance and yield components of red rice.

II. Material And Methods

Treatments and design

In this study, the field experiment was carried out in an entisol irrigated rice-land in Beleke village of West Lombok, Indonesia (116°7'54" E; 8°39'29" S), from May to August 2018. The experiment was arranged according to Split Plot Design in three blocks (replications) with two treatment factors i.e. techniques (T) of growing rice plants as the main plot factor, consisting of three treatments (T0= conventional rice; T1= aerobic rice grown on raised-beds (under aerobic irrigation system) without intercropping with peanut; T2= aerobic rice on raised-beds additive intercropped with peanuts), and patterns (P) of rice rows as the sub-plot factor, consisting of three treatments (P1= normal or single-row; P2= double-row; P3= triple-row pattern, as shown in Figure 1).

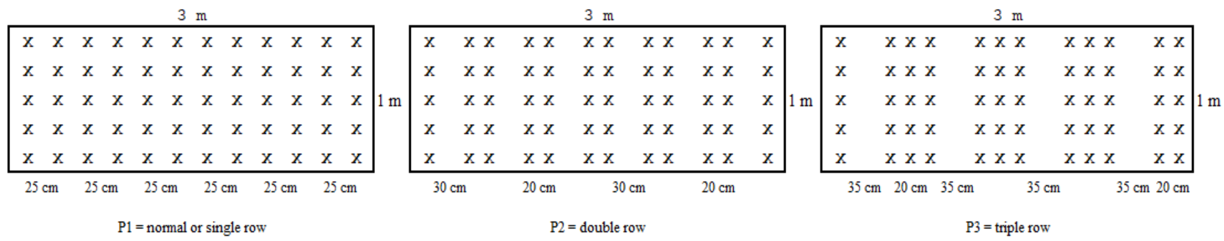

Figure 1. Patterns of rows of the red rice plants on the raised-beds and conventional plots of monocropped rice plants

Implementation of the experiment

Before the raised-beds were made, soil tillage was done by once plowing and once harrowing in dry conditions. Then, raised-beds were made with a surface bed size of 1 m x 3 m, surrounded by furrows of 35 cm wide and 25 cm deep. Between the main plot of conventional (flooded irrigation) and raised-bed growing systems, a separating dike of 30 cm wide was build to maintain standing water on the conventional plots of 10 cm during irrigation days, while irrigation for the raised-bed system was done by flowing the irrigation water in the furrow with the water surface of around 10 cm below the raised-bed surface, so that the upper 10 cm soil of the raised-beds can be in aerobic condition during the irrigation process (aerobic irrigation system). Unlike preparing the raised-beds, soil tillage for the conventional plots was done by once plowing and once harrowing under flooded conditions to facilitate formation of puddled soil conditions. After that, the plot was regularly flooded until the next soil tillage was done for transplanting preparation. Three days before transplanting the rice seedlings, the conventional plot was plowed and harrowed once again to improve puddling the soil, and the soil was maintained under thin standing water until transplanting time.

The pre-germinated seeds of the promising line of amphibious red rice "AM-4" were dibbled by burying 3-4 seeds per planting hole with a base spacing of 25x20 cm in the normal row pattern (Fig. 1). The AM-4 (F2BC4A86-3) promising line was the result of hybridization and backcrossing one of the results, i.e. S-F2BC4AKBC52-16-22-18 with local cultivar "Kala Isi Tolo (KIT)", and based on a multi-location yield test, the AM-4 promising line was identified as an amphibious line of red rice (Aryana and Wangiyana, 2016). For the double and triple row patterns, the base spacing of 25x20 cm was modified in such a way so that the planting distances are as in Fig. 1. For the T2 treatment (rice-peanut intercropping), one row of peanut seeds were dibbled between single, double or triple-row at 2 weeks after seeding (WAS) of pre-germinated rice seeds, by burying 2-3 peanut seeds that had been soaked for 12 hours and seed-coated with *Rhizobium* inoculant prior to planting the coated seeds, at a planting distance of 20 cm within row. The peanut variety used, i.e. "Bison" variety (an Indonesian national superior variety), was supplied by the Institute of Research for Pulse and Root Crops (Balitkabi), Malang, Indonesia, and according to the variety description supplied by this Institute, this variety of peanut has some shade tolerance of up to 25% shading.

The remaining of the pre-germinated red rice seeds, after planting on the raised beds, were broadcasted on the nursery bed to produce rice seedlings for transplanting onto the conventional plots at the age of 21 DAS as the normal farmers' practices for growing conventional rice plants. The nursery seedlings were fertilized with Phonska (NPK 15-15-15) fertilizer of 30 g/m^2 before seeding. Three days before transplanting, the conventional plots were plowed and harrowed once again under flooded condition to facilitate puddling; then the plots were thin flooded until the time of transplanting. At transplanting, three seedlings were planted per planting hole, with the same planting space and row patterns as in the aerobic system.

For rice plants on the raised-beds, thinning the rice plants was done at the age of 7-8 days after seeding (DAS) by leaving to grow only 2 young rice plants per planting hole; then base fertilizer was applied by dibbling Phonska fertilizer at a dose of 300 kg/ha (1.5 g/clump) into a fertilizer hole of 7 cm deep and 7 cm beside the young rice plants within the rice row. Thinning of peanut young plants was carried out at the age of 9-10 DAS by leaving to grow only 2 peanut plants per planting hole. Then the peanut plants were fertilized with Phonska (15-15-15) at 200 kg/ha by dibbling the fertilizer about 7 cm next to the peanut plants as deep as 7 cm in line with the peanut row. Additional fertilization of the rice plants is normally done twice using Urea (45% N) fertilizer at a dose of 100 kg/ha each, but because in this research, the objective was to examine the effect of additive intercropping with a legume crop (i.e. peanut), N fertilization was done only once, i.e. at the age of 7 WAS using Urea at a dose of 100 kg/ha (0.5 g/clump). The Urea was dibbled between rice clumps at 7-8 cm depth in line with the rice row on the raised-beds. For fertilization of the conventional rice plants, the Phonska fertilizer (90 g/plot) was broadcasted on the plots prior to transplanting the seedlings, while Urea fertilizer (30 g/plot) was broadcasted on the plots at 30 days after transplanting, while the standing water was maintained very thin on the plot, as what are normally done by the farmers.

Other crop maintenance included weeding, irrigating and spraying pesticides for pest control. Weeding was done at the ages of 2, 4, 6, 8 WAS. Irrigation water was supplied when the standing water on the conventional plots has sunk to very thin (less than 1 cm), which was every 3-5 days, by maintaining standing water of up to 10 cm on the conventional plots and flooding the furrows surrounding the raised-beds up to 10 cm below the bed surface during the irrigation day, then the irrigation water was stopped for coming and leaving the experimental field. For controlling *Leptocorisa acuta*, several sprays of emulsion of Reagent 50 SC (a.i. Fipronil 50 g/L), alternating with Decis 25 EC (a.i. Deltametrin 25 g/L), every week since anthesis, based on the recommendation. To avoid bird attack, the entire experimental beds and plots were full-covered with white nylon net at 2 m height by supporting the net with bamboo sticks since anthesis. Harvest of the rice panicle was done at 110 DAS, and harvest of the peanut plants was done at 100 DAS.

Observation variables and data analysis

Observation variables include plant growth and yield components as the measures of yield formation strength, as listed in Table 1. The percentage of unfilled grain number was the percentage fraction of unfilled grain number divided by total spikelet number per clump. The data were analyzed with ANOVA (analysis of variance) and Tukey's HSD test at 5% level of significance using "CoStat for Windows" ver. 6.303.

III. Result and Discussion

The summary of ANOVA results in Table 1 shows that rice cultivation techniques had significant effects on tiller number per clump, plant height at anthesis, dry straw weight, filled panicle number per clump, average panicle length, filled grain number per clump, and percentage of unfilled grain number. Patterns of rice rows also had significant effects on dry straw weight, filled panicle number, average panicle length, and filled grain number per clump. However, there was a significant effect of the treatment factors on plant height at anthesis and filled grain number per clump.

Table 1. Summary of ANOVA results for all observation variables

Observation variables	Cultivation Technique	Row Patterns	Interaction
Clump size (tiller number per clump)	***	ns	ns
Plant height at anthesis	***	ns	*
Dry straw weight per clump	***	**	ns
Percentage of filled tiller number	ns	ns	ns
Filled panicle number per clump	***	*	ns
Average panicle length	*	*	ns
Filled grain number per clump	***	**	**
Percentage of unfilled grain number	**	ns	ns

Remarks: ns= non-significant; *, **, *** = significant at *p-value* <0.05, *p-value* <0.01 and *p-value* <0.001 respectively

Based on the patterns of the interaction between both treatment factors on plant height (Fig. 2.A), it appears that the red rice plants were taller in single-row under aerobic irrigation systems intercropped with peanut, but they were shorter under conventional and aerobic system without intercropping with peanut. A similar pattern of interaction seems to occur in relation to filled grain number per clump, as can be seen from Fig. 2.B.

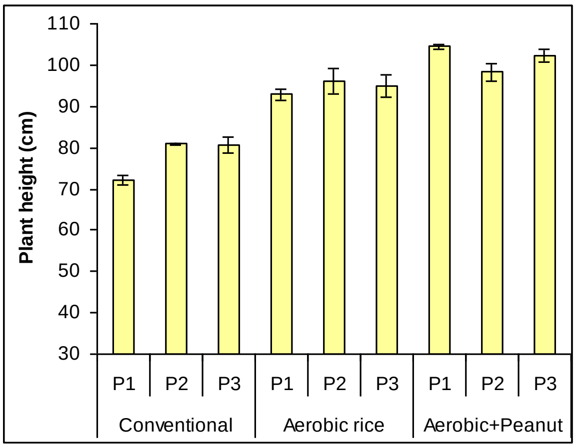

Figure 2.A. Average height (Mean ± SE) of red rice plants as affected by cultivation techniques and patterns of rice rows

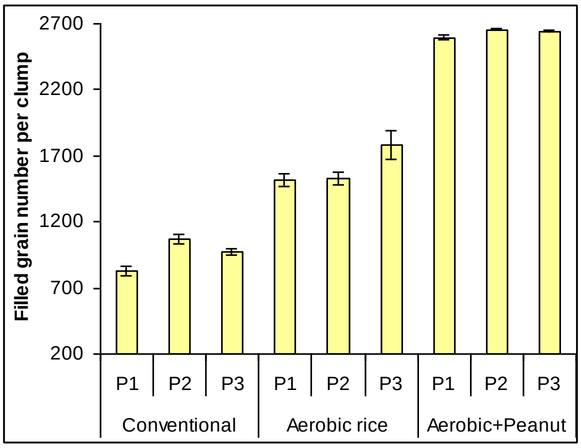

Figure 2.B. Average number (Mean ± SE) of filled grains of red rice plants as affected by cultivation techniques and patterns of rice rows

The non-significant differences in filled grain number between patterns of rice rows in the aerobic system intercropped with peanut as opposed to those in the conventional rice indicate some contribution of peanut plants relay planted between every single row of red rice plants in the intercropping system. This also means that the closer distance between peanut and rice plants in the single-row pattern compared with double- or triple-row pattern had improved yield formation potentials of the red rice in single-row pattern than in double or triple row pattern. In double-row pattern, the proportion of rice to peanut population was 2:1 while in the triple-row pattern it was 3:1. According to the results reported by Fujita *et al.* (1990), the rate of N transfer from soybean to sorghum was higher in closer distances between soybean and sorghum plants in the intercropping system. This could also be the case in this field experiment since peanut plants are also capable of fixing atmospheric nitrogen through symbiosis with *Rhizobium* sp. The peanut seeds were seed-coated with *Rhizobium* inoculant prior to relay planting between rows of rice plants, and those peanut plants also produced root nodules in the field.

Better and more aerobic rhizosphere conditions could also be the main causes for better growth of the rice plants in the aerobic and aerobic system intercropped with peanut compared with that of the rice plants in the conventional system, especially in terms of tiller number and biomass or dry straw weight, which is part of the biomass production (Table 2). As what happen in the SRI compared with conventional system, the higher tiller number and growth of rice plants is attributed to more aerobic soil conditions in the SRI, which facilitates better development and activities of soil microbes supporting plant growth, such as biological nitrogen fixers and phosphate solubilizers in the more aerobic than inundated system in the conventional techniques of growing rice (Uphoff, 2003). Dulur *et al*. (2015) also reported higher tiller number in rice plants under aerobic than conventional irrigation systems. Higher yield of rice plants was also obtained from rice plants grown in intercropping with soybean than in conventional system (Dulur *et al*., 2016). Farida *et al*. (2016) also reported that the number of tillers and panicles per clump was much higher in rice plants intercropped with peanut plants in aerobic rice systems on raised-beds compared with those without intercropping with peanut.

Tabel 2. Average tiller number per clump, plant height, dry straw weight, and percentage of panicle number of red rice between treatments of each factor

Treatments	Tiller number per clump	Plant height (cm) at anthesis	Weight of dry straw (g/clump)	Percentage of panicle number
T0: conventional	19.8 c	77.9 c	25.58 c	97.7 a
T1: aerobic rice	21.2 b	94.6 b	34.48 b	97.4 a
T2: aerobic+peanut	27.2 a	101.6 a	38.94 a	98.6 a
Tukey's HSD	1.2	4.8	3.96	7.6
P1: single-row	22.1 a	89.8 a	29.83 b	95.8 a
P2: double-row	23.3 a	91.7 a	34.13 a	99.1 a
P3: triple-row	22.8 a	92.6 a	35.05 a	98.7 a
Tukey's HSD	1.6	3.9	3.34	4.9

Remarks: Means in the same column followed by the same letters are not significantly different between treatments of each factor based on their Tukey's HSD at 5% level of significance

In relation to the potentials of the rice plants to produce higher number of filled grains per clump, hence higher potential of yield formation, it can be seen from Table 3 that growing the red rice plants under aerobic irrigation systems or aerobic system intercropped with peanut plants significantly increased the potentials when compared with applying conventional rice growing technique. These could be due to the more aerobic conditions of the rice rhizosphere, which further better supported by the presence of peanut plants, which have the potential for improving N nutrition of the rice plants in intercropping with peanut (Chu *et al*., 2004), which was also reported to happen in intercropping of maize and peanut (Inal *et al*., 2007). In relation to patterns of rice rows, based on the main effects, filled grain numbers were higher on double and triple rows than on single-row pattern (Table 3).

Tabel 2. Average panicle number per clump, panicle length, filled grain number, and percentage of unfilled grain number of red rice between treatments of each factor

Treatments	Panicle number per clump	Average panicle length (cm)	Filled grain number per clump	Percentage of unfilled grain number
T0: conventional	19.3 b	19.8 b	953.7 c	5.0 b
T1: aerobic rice	20.7 b	20.1 b	1609.1 b	8.8 a
T2: aerobic+peanut	26.8 a	21.9 a	2632.3 a	4.5 b
Tukey's HSD	1.5	1.7	162.2	2.5
P1: single-row	21.2 b	19.9 b	1645.7 b	5.9 a
P2: double-row	23.1 a	20.6 ab	1750.8 a	6.5 a
P3: triple-row	22.5 ab	21.2 a	1798.7 a	5.9 a
Tukey's HSD	1.7	1.0	82.1	1.9

Remarks: Means in the same column followed by the same letters are not significantly different between treatments of each factor based on their Tukey's HSD at 5% level of significance

However, there was a significant interaction effect of the two factors (Fig. 2), indicating that positive contribution of intercropping with peanut plants was higher in single than in double or triple row patterns, especially when compared with the conventional system, in which filled grain number was the lowest in the single-row pattern, but it was not significantly different between patterns of rice rows in rice intercropped with peanut. This could be because N transfer from peanut to rice (Chu *et al*., 2004) was higher in the single-row pattern due to closer distance between both crops which could improve involvement of AMF in the N transfer through better chances for formation of AMF hyphal bridges (Bethlenfalvay *et al*., 1991; Hamel and Smith, 1991; Smith and Read, 2008) since both peanut and rice plants are categorized as mycorrhizal crops (Anderson and Ingram, 1993). Wangiyana *et al*. (2017) also reported that AMF inoculation of red rice intercropped with several varieties of peanut under aerobic irrigation systems significantly increased panicle number and grain yield per clump compared with the uninoculated rice plants.

IV. Conclusion

It can be concluded that improvement of yield formation potentials can be achieved by growing the red rice plants under aerobic irrigation systems or aerobic system intercropped with peanut plants instead of applying the conventional rice growing technique. However, there was a significant interaction effect of the two factors showing that positive contribution of intercropping with peanut plants was higher in single than in double or triple row patterns, especially when compared with the conventional system.

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References

[1]. Anderson, J.M. and Ingram, J.S.I. 1993. Tropical Soil Biology and Fertility: A Handbook of Methods. 2nd edition. CAB International, Wallingford, UK.

[2]. Bethlenfalvay G.J., Reyes-Solis, M.G., Camel, S.B. and Eerrera-Cerrato, R. 1991. Nutrient transfer between the root zones of soybean and maize plants connected by a common mycorrhizal mycelium. *Physiologia Plantarum*, 82: 423-432.

[3]. Bouman, B.A.M. 2001. Water efficient management strategies in rice production. *International Rice Research Notes*, 16(2): 17–22.

[4]. Chu, G.X., Shen, Q.R. and Cao, J.L. 2004. Nitrogen fixation and N transfer from peanut to rice cultivated in aerobic soil in an intercropping system and its effect on soil N fertility. *Plant and Soil*, 263: 17–27.

[5]. Dulur, N.W.D., Farida, N., Wiresyamsi, A. and Wangiyana, W. 2015. Growth of Several Amphibious Red Rice Lines between Conventional and Aerobic Systems Intercropped with Soybean. *International Journal of Agriculture and Crop Sciences*, 8(5): 774-778.

[6]. Dulur, N.W.D., Farida, N., Wiresyamsi, A. and Wangiyana, W. 2016. Yield of Two Red Rice Genotypes between Flooded and Aerobic Rice Systems Intercropped With Soybean. *IOSR - Journal of Agriculture and Veterinary Science*, 9(12), Ver.II: 01-06.

[7]. Farida, N., Abdurrachman, H., Budidanto, V.F.A. and Wangiyana, W. 2016. Growth Performance of Red Rice as Affected by Insertion of Peanut Row between Double and Triple-Rows of Rice in Aerobic System on Raised-Beds. Proceedings of the First International Conference on Science and Technology (ICST-2016). University of Mataram, p. 191-196.

[8]. Fauzi, A. 16-01-2018. Begini perjalanan impor beras Indonesia sejak tahun 2000 hingga 2018. Kompas, 16-01-2018. https://ekonomi.kompas.com/read/2018/01/16/161052826/begini-perjalanan-impor-beras-indonesia-sejak-tahun-2000-hingga-2018.

[9]. Fujita, K., Ogata, S., Matsumoto, K., Masuda, T., Ofosu-Budu, G.K. and Kuwata, K. 1990. Nitrogen Transfer and Dry Matter Production in Soybean and Sorghum Mixed Cropping System at Different Population Density. *Soil Sci. Plant Nutr*., 36(2): 233-241.

[10]. Hamel, C. and Smith, D.L. 1991. Interspecific N-transfer and plant development in a mycorrhizal field-grown mixture. *Soil Biology and Biochemistry*, 23: 661-665.

[11]. Inal A., Gunes A., Zhang F., Cakmak I. 2007: Peanut/maize intercropping induced changes in rhizosphere and nutrient concentrations in shoots. *Plant Physiology and Biochemistry*, 45: 350-356.

[12]. Prasad, R. 2011. Aerobic Rice Systems. *Advances in Agronomy*, 111: 207-247. DOI: http://dx.doi.org/10.1016/B978-0-12-387689-8.00003-5.

[13]. Smith, S.E. and Read, D.J. 2008. Mycorrhizal Symbiosis. Third Edition. London, UK: Academic Press.

[14]. Thompson, J.P. 1991. Improving the mycorrhizal conditions of the soil through cultural practices and effects on growth and phosphorus uptake by plants. In: C. Johansen, K.K. Lee and K.L. Sahrawat (Eds), Phosphorus Nutrition of Grain Legumes in the Semi-Arid Tropics. ICRISAT: Patancheru, India. p.117-137.

[15]. Uphoff, N. 2002. Question and answer about the System of Rice Intensification (SRI) for raising the productivity of land, labor and water. CIIFAD (Comell International Institute for Food, Agriculture and Development) Paper, available at SRI webpage (http://ciifad.comell.edu/sri/sripapers.html).

[16]. Uphoff, N. 2003. Higher Yields with Fewer External Inputs? The System of Rice Intensification and Potential Contributions to Agricultural Sustainability. *Intl J Agric Sustainability*, 1(1):38-50.

[17]. Vejsadová, H., Siblikova, D., Hršelová, H., and Vančura, V. 1992. Effect of the VAM fungus Glomus sp. on the growth and yield of soybean inoculated with Bradyrhizobium japonicum. *Plant and Soil*,140: 121-125.

[18]. Wangiyana, W., Aryana, I.G.P.M., Gunartha, I.G.E. and Dulur, N.W.D. 2017. Effects of Inoculation with Arbuscular Mycorrhizal Fungi on Growth and Yield of Promising Line of Red Rice Grown together with Several Peanut Varieties. *IOSR - Journal of Agriculture and Veterinary Science*, 10(9), Ver.II: 18-23. DOI: 10.9790/2380-1009021823.

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