PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 14 (6): 362-365, 2015
ISSN 1680-5194

Effect of Intercropping Between Corn (*Zea mays*) and Peanut (*Arachis hypogaea*) with Arbuscular Mycorrhizal (AMF) on the Yield and Forage Mineral Content

Nyimas Popi Indriani[1], Yuyun Yuwariah[2], Ana Rochana[1] and Harun Djuned[1]
[1]Faculty of Animal Husbandry, [2]Faculty of Agriculture,
Padjadjaran University, Bandung, West Java, Indonesia

Abstract: The study aimed to analyze the cropping pattern of intercropping between maize plants and peanut with arbuscular mycorrhizal fungi inoculated on yield and mineral content of forage. Field experiments used a split plot design with main plots were intercropping patterns (TS) consist of three kinds: TS 1:1, TS 1:2 and TS 2:1. The subplots were the single AMF inoculation consisted of four kinds: m_1 (*Glomus etunicatum*), m_2 (*Glomus manihotis*), m_3 (*Gigaspora margarita*) and m_4 (*Acaulospora* sp). The experiment was replicated three times, then the number of plots were 36. Agronomic parameters measured were fresh weight of corn crop and fresh weight of baby corn residues, calcium content of corn plant and of baby corn residues, calcium content of peanut plant, phosphorus content of corn plant with baby corn residues and phosphorus content of peanut plants. The experimental results showed that: (1) The effect of the interaction did not occur between the cropping patterns of intercropping system with a single AMF inoculation on yield and forage minerals. (2) The content of Ca (calcium) and P (phosphorus) of corn crop with baby corn residues on the cropping pattern of intercropping system with FMA inoculated were the same, Ca on TS 1:1 (0.51%), TS 1:2 (0.57%) and TS 2:1 (0.47%) and the content of P (phosphorus) in the TS 1:1 (0.14%), TS 1:2 (0.15%) and TS 2:1 (0.14%). (3) The content of Ca (calcium) of peanut plants at planting pattern of intercropping systems with FMA inoculated at TS 1:2 (1.65%) and 2:1 (1.76%) were higher than at TS 1:1 (1.45%), while the content of P (phosphorus) were similarly at TS 1:1 (0.162%), TS 1:2 (0.184%) and TS 2:1 (0.169%). (4) The fresh weight of corn crops together with baby corn residues on the cropping pattern of intercropping system with FMA inoculated were equals; TS 1:1 (36.36 tones/ha/harvest), TS 1:2 (32.75 tones/ha/harvest) and TS 2:1 (35.66 tones/ha/harvest). The peanut plant fresh weights were not significantly different among TS 1:1 (3.99 tones/ha/harvest), TS 1:2 (6.70 tones/ha/harvest) and TS 2:1 (2.30 tones/ha/harvest). Providing a single AMF inoculation has no effect on fresh weight, Ca and P of groundnut and of maize crops together with baby corn residues.

Key words: Intercropping row, AMF, forage

INTRODUCTION

Forage generally consists of grasses (Gramineae) and legumes (Leguminoseae) as basic requirement of ruminants and are needed in large quantities. The feed availability generally depend on local farming systems. Feed crops planted in single system and continuously have low performance and need to be improved to increase the benefit value. Forage results of corn plant and peanuts plant can be used for ruminants because of the high content of fiber and palatable. This is an important ruminant feed when the grass is insufficient, especially in the dry season.

Cropping pattern row intercropping system can improve the productivity of agricultural land and crops if the types of plants that are combined in this system do not compete each other in terms of sunshine, taking water and nutrients. Another advantage gained from intercropping planting patterns are ability to provide the balance of nutrients, as control of weeds, maintain soil fertility, prevent erosion and prevent the tendency of increase in pests and reduce the risk of harvest crop failure.

In a system of sustainable agriculture and low 'input', the role of micro-organisms mycorrhizae in maintaining soil fertility and biocontrol of soil pathogens is important rather than conventional agriculture that has been limited by higher 'input' of 'Agrochemical'. Provision of artificial fertilizer (chemical fertilizer) can cause environmental pollution. A deeper understanding of the interaction between mycorrhizal with other microorganisms is necessary to develop a sustainable management of soil fertility and crop yields. The presence of other microorganisms such as Rhizobium can provide benefits for mycorrhizal because Rhizobium inoculant can help mycorrhizal propagules in the phosphorus deficiency soil. Intercropping also can help

Corresponding Author: Nyimas Popi Indriani, Faculty of Animal Husbandry, Bandung, Padjadjaran University, West Java, Indonesia

the spread of microorganisms such as symbiotic arbuscular mycorrhizal fungi indigenous in the soil. Relationship between soil microorganisms, such as FMA (Fungi Mycorrhizal Fungi), is an important part of the farm, but the interaction is still limited understood.

Baby-corn maize crop is harvested shorter than maize-producing corn, so the forage crop is very good condition, fresh and palatable. Baby corn is a corn harvested at a young age, but the structure and function similar to the corn crop. For each corn plant corn cob could be picked 3-5 baby corn depend on corn crop planting. Harvesting is done before pollination or at the time of main cob yet fully developed, can be done by breaking the male flowers to form more corncobs as baby corn. To support the high production of baby corn needs superior maize crop varieties. Almost all varieties of hybrid maize corn could be potentially be harvested as baby corn.

The combination of corn and peanut crops in intercropping can increase the productivity of the soil and the plant itself. This is due to the compatibility of several properties owned both of these plants. Corn plants require high light intensity for photosynthesis, grow tall, erect, unbranched and loose canopy allows for other plants growing underneath. Fibrous root system of maize plants need nitrogen in large quantities. Peanut plants are shade-tolerant plants, grow short, erect, with a taproot system forming nodules capable in symbiotic N2 fixation by *Rhizobium* sp. The element nitrogen fixation results utilized by bacteria and host for growth and partly utilized by other plants in the surrounding areas like baby corn crop and the rest into the ground (Tarmudi, 1999).

Peanut plants are a source of protein and minerals forage for ruminants in the tropics. This plant is sensitive to nutrient phosphorus (P) deficiency and currently has been addressed with superphosphate fertilizer. Inorganic fertilizer (superphosphate) awarded to the ground continuously will cause damage to the soil so plants stunted and decreased crop quality. High prices of superphosphate fertilizer causes attention shifted to the use of organic fertilizer, natural phosphate fertilizer or also called 'rock phosphate'. Rock phosphate, slowly available to plants, therefore it needs a technology that can improve nutrient P and rock phosphate fertilizer for example with the help of the FMA. Plants inoculated with AMF, utilizing more soluble phosphorus from natural phosphate than the plants that do not contain mycorrhizae. Given natural phosphate concentration affects the plant's dependence on the FMA. AMF hyphae also help the absorption of other nutrients such as nitrogen which is needed both by peanut and corn crops. Cruz *et al*. (2002) explained that some of the root exudates of AMF infected host plants increase *in vitro* germination of spores and hyphae growth of Gigaspora Margaritha compared to plants without AMF infected. Root exudates of poncirus trifoliate (trifoliate orange), bahia grass Pennisetum qlaucum stimulate the growth of plants containing hyphae of Gigaspora Margaritha *in vitro*. Another possibility is the increase in the density of hyphae on intercropping cropping pattern is due to the density of plant roots in the mixture than single cropping pattern.

MATERIALS AND METHODS

Materials: Chemical analysis equipment plant tissue. The materials used in third stage of this research are: (1) The seed of maize (*Zea mays* L.); (2) Plant seeds of peanut (*Arachis hypogaea*); (3) single FMA multiplication results in polybag (*Glomus manihotis*, *Etunicatum glomus*, *Gigaspora margarita and Acaulospora* sp) and (4) 'rock phosphate'.

Methods and analysis

Design of experiments: The experimental design was performed using Separate plot design (Split Plot Design) and the combination treatment was repeated three times. Intercropping line system as the main plot consisting of three treatments, namely:

1: Intercropping 1: 1 (TS 1: 1)
2: Intercropping 1: 2 (TS 1: 2)
3: Intercropping 2: 1 (TS 2: 1)

whereas the type of mycorrhiza is placed as the subplot factor that consists of 4 types:

1: *Glomus etunicatum* (m_1)
2: *Glomus manihotis* (m_2)
3: *Gigaspora margarita* (m_3)
4: *Acaulospora tuberculata* (m_4)

Experiments cropping row intercropping system TS 1: 1 is one row of corn and one row of peanut crop. TS 1: 2 is one row of corn and two rows of peanut plants. TS 2: 1 is two rows of corn and one peanut crop row.

Response plan: Agronomic parameters measured were fresh weight, Ca and P content of corn crop corn and residual harvest baby corn and peanut plants.

RESULTS AND DISCUSSION

Fresh weights of corn crop along with baby corn harvest residual and peanut crops in intercropping raw system and FMA inoculation: The average fresh weight of corn crop is not affected by cropping patterns and types of mycorrhizae. Fresh weight of the corn crop in the cropping pattern line intercropping TS 1:2 (32.75 tones/ha/crop) is statistically the same as TS 1:1 (36.36 tones/ha/crop) and TS 2:1 (35.66 tones/ha/crop), can be seen in Table 1. In the cropping pattern intercropping 1:2 the most density peanut plants

Table 1: Average fresh weight of corn on intercropping line and type FMA treatments

	Corn crop	Peanut plant
Crop pattern	--------- Fresh weight (ton/ha/harvest) --------	
TS 1: 1	36.36[a]	3.99[a]
TS 1: 2	32.75[a]	6.70[a]
TS 2: 1	35.66[a]	2.30[a]
FMA		
Glomus etunicatum	36.72[a]	4.26[a]
Glomus manihotis	34.05[a]	4.10[a]
Gigaspora margarita	35.45[a]	4.62[a]
Acaulospora sp	33.49[a]	4.33[a]
Interaksi	tn	

Numbers in the column followed by different letters are significantly different according to Duncan advanced test at 5% level

Table 2: Average content of phosphorus and calcium in maize on row intercropping and FMA type treatment

	Phosphorous content	Calcium content
Crop pattern	---------- Corn crop (%) ----------	
TS 1: 1	0.14[a]	0.51[a]
TS 1: 2	0.15[a]	0.57[a]
TS 2: 1	0.14[a]	0.47[a]
FMA		
Glomu setunicatum	0.15[a]	0.47[a]
Glomus manihotis	0.15[a]	0.47[a]
Gigaspora margarita	0.14[a]	0.52[a]
Acaulospora sp	0.14[a]	0.48[a]
Interaksi	tn	tn

Numbers in a column followed by different letters are significantly different according to Duncan advanced test at 5%

Table 3: Average content of phosphorus and calcium in peanu plant on raw intercropping and type FMA treatment

Crop pattern	Phosphorous content (%)	Calcium content (%)
TS 1: 1	0.16[a]	1.45[b]
TS 1: 2	0.18[a]	1.65[a]
TS 2: 1	0.17[a]	1.76[a]
FMA		
Glomus etunicatum	0.17[a]	1.55[a]
Glomus manihotis	0.17[a]	1.71[a]
Gigaspora margarita	0.18[a]	1.67[a]
Acaulospora sp	0.16[a]	1.56[a]
Interaksi	tn	tn

Numbers followed by different letters in a column are significantly different according to Duncan advanced test at 5% level

can yield corn plant fresh weight equal to TS 1: 1 and TS 2: 1, this means peanut plants greatly affect the fresh weight of the corn crop. The more the population of peanut plants, the more nitrogen donations given for corn.

In accordance with the study of Njoka-Njiru *et al.* (2006) the increase in fresh weight of grass plants results for soil fertility increases with the presence of nitrogen fixation by legumes that were obtained from atmospheric nitrogen fixation, nodule dead decay and mineralization of the fall leaves. Khan (2005) reported that mycorrhiza is an important component of the ecosystem, can affect the development of plant community composition and ecosystem function. Fresh weight generally influenced by the relative humidity of the surrounding atmosphere at harvest and during storage time (Musa *et al.*, 2011).

Table 1 shows the cropping pattern row intercropping system TS 1: 1, TS 1:2 and TS 2:1, the results of the fresh weight of peanut plants were not significantly different. Fresh weight of peanut plants that were not significantly different alleged that the carrying capacity of the environment is not a limiting factor. Peanut plants are C3 plants cover the ground so that maintain soil moisture and fertility and tolerance to shade.

Intercropping cropping patterns support the ability of plants to exploit the different components of the soil layer without competing with each other. Corn and peanut yield production of fresh weight is greater than a single plant (Eskandari, 2012). The formation of the ideal number of plants is an important point to determine or obtain the maximum benefit when different plant species grown together (Margado and Willey, 2008).

Phosphorus and calcium content in maize, as well as phosphorus, calcium and iron content in peanut plant on intercropping raw system and FMA type inoculation treatment: In the Table 2. The average calcium content of the corn crop, TS 1: 1 (0.51%), TS 1: 2 (0.57%) and TS 2: 1 (0.47%), was not affected by treatment of row intercropping cropping pattern and mycorrhizal types (Table 2). High plant density on TS 1: 2 contains as much calcium as intercropping cropping pattern TS 1: 1 and TS 2; 1, this means that the availability of calcium in the soil is sufficient for the cropping pattern with the highest density is at TS 1: 2.

The average content of phosphorus in corn crop intercropping cropping pattern TS 1: 2 (0.15%) were not significantly different compared to TS 1: 1 (0.14%) and TS 2: 1 (0.14%). This means that the availability of phosphorus in the soil sufficient for cropping pattern intercropping system and AMF inoculation.

FMA was able to improve the function and role of roots in using water and nutrients, as well as facilitated the plants to absorb nutrients, especially P. Mycorrhizae was able to provide and release nutrients bounded or trapped on the clay particles and provided more raw materials in the process of photosynthesis so phosphorus and calcium contain in maize plant was maximum.

Mycorrhizae Fungi can increase vegetative and reproductive growth of plants. Speed entry of nutrients, especially P into FMA fungal hyphae can reach six times faster than the entry of P through the root hairs (Kabirun, 2002).

Content of phosphorus, calcium and Fe in peanut crops on raw intercropping system and provision of AMF inoculation are presented: The average phosphorus content of peanut plants in the cropping pattern intercropping TS 1: 2 (0.18%) was not significantly different from TS 1: 1 (0.16%) and TS 2: 1 (0.17%), it can be seen in Table 3 and are not affected by

the type of mycorrhiza. Phosphorus is important in plant metabolism, cellular energy transfer, respiration and photosynthesis (Irmak, 2012). ATP formation in plants requires the availability of nutrients P and mycorrhizae can improve the absorption of nutrients, especially nutrient P. ATP required for plant metabolic processes (Tanaka and Makino, 2009).

The average calcium content of peanut plants in the cropping pattern intercropping line 1: 2 (1.65%) was significantly different from TS 1: 1 (1.45%) and was not significantly different with TS 2: 1 (1.76%). This is consistent with research conducted by Dunea and Motca (2007) that the calcium of Trifolium in the range between 1.41 to 1.93%.

Conclusion: Based on the review of the results of research on growth, yield and quality of forage produced from intercropping row system between corn and peanut plants inoculated with AMF can be concluded the following matters:

1: Effect of intercropping row systems and the provision of inoculation FMA, do not interact each other on all the variables measured and observed in fresh weight, Ca and P of corn crop with baby-corn residual harvest and peanut plants
2: The fresh weight production of baby-corn crop in intercropping planting pattern and AMF inoculation are the same
3: Cropping pattern intercropping TS 1:2 is the best producer of green forage

REFERENCES

Cruz, A.F., T. Ishi, I. Matsumoto and K. Kadoya, 2002. Network establishment of vesicular-arbuscular mycorrhizal hyphae in the rhizospheres between trifoliate orange and some plant. J. Jpn. Soc. Hort. Sc., 71: 19-25.

Dunea, D. and G.H. Motca, 2007. Forage quality assessments of red clover (*Trifolium pratense* L.) through near infrared spectroscopy. Lucrari Stiinfice Zootechniesi Biotechnologii, 40: 274-283.

Eskandari, H., 2012. Yield and Quality of forage produced intercropping of maize (*Zea mays*) with cowpea (*Vigna sinensis*) and mungbean (*Vigna radiate*) as double cropped. J. Basic. Appl. Sci. Res., 2: 93-97.

Irmak, S., A.N. Cil, H. Yucel and Z. Kaya, 2012. The effect of Iron application to soil and foliarly on agronomic properties and yield of peanut (Arachis hypogaea). J. Food Agri. Environ., 10: 417-422.

Khan, A., 2005. Role of soil microbes in the rhizosphere of plants growing on trace metal contaminated soil in phytoremediation. J. Trace Elements in Med. and Biol., 18: 355-364.

Kabirun, S., 2002. Tanggap Padi Gogo Terhadap Inokulasi Mikoriza Arbuskula dan Pemupukan Fosfat di Entisol. J. Tanah dan Lingkungan, 3: 49-56.

Margado, L.B. and R.W. Willey, 2008. Optimum plant population for maize-bean intercropping system in the Brazilian Semi-Arid region. Sci. Agric., 65: 474-480. Apa sifat fisika tanah akibat pemadatan tanah ultisol. J. Komunikasi Penelitian, 17: 48-52.

Musa, E.M., E.A.E. Elsheikh, I.A.M. Ahmed and E.E. Babiker, 2011. Effect of intercropping with cowpea (*Vigna unuiculata* L) Bradyrhizobium inoculation and fertilization on physical and biochemical quality of sorghum (*Sorghum bicolor* L) seeds. Electronic J. Environ. Agric. and Foodche, 10: 3064-3075.

Njoka-Njiru, E.N., M.G. Njaru, S.A. Abdul-Razak and J.G. Mureithi, 2006. Effect of intercropping herbaceous legumes with naiper grass on dry matter yield and nutritive value of the feed stuffs in semi-arid region of east tern Kenya. Agric. Trop. et Subtropica, 39: 255-267.

Tanaka, A. and A. Makino, 2009. Photosynthetic research in plant science. Plant Cell Physiol., 50: 681-683.

Tarmudi, A.R., 1999. Pengaruh Proses Biokonversi Ampas Tebu oleh Jamur Tiram Putih (*Pleurotus ostreatus*) terhadap Nilai Nutrisi dan Pemanfaatannya sebagai Campuran Ransum Domba Priangan. Disertasi Program Pascasarjana Universitas Padjadjaran. Bandung.