Nutrient concentration of nitrogen and phosphorus on intercropping of several varieties maize and soybean in dryland North Lombok, Indonesia

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Nutrient concentration of nitrogen and phosphorus on intercropping of several varieties maize and soybean in dryland North Lombok, Indonesia

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Abstract The reduction in agricultural land due to land conversion and climate change has encouraged several technological innovations in cultivation systems, including intercropping planting patterns in dryland. Dryland is a potential future as productive agricultural land and to improve the efficiency of land use and the intercropping system is an option in agricultural cultivation. The objective of this research was to determine the nutrient concentration of nitrogen and phosphorus on intercropping several varieties of maize and soybean in dryland. The method used in this study was a randomized block design with 5 treatment intercropping varieties combination of maize and soybean, namely V1 = NK212: Biosoy I, V2 = Bima 20 URI: Dega I, V3 = NASA 29: Detap, V4 = Bisi 18: Biosoy II, V5 = Srikandi Kuning: Anjasmoro. Each treatment was repeated three times to obtain 15 experimental plots. Parameters that were observed in this study, namely, the concentration of N, P, organic C content and pH of the soil at 40 das (day after seedling) and 92 das, uptake of N and P per plant at 40 das. Data were analyzed using analysis of variance at 5% significance level and if the treatment was significantly different then further tested using LSD at 5% significance level. The impact of climate change is the occurrence of a shift in the nutrient concentration of N, P, C-organic content, and pH in the soil at 40 or 92 das and the uptake of N and P nutrients in the plants at 40 das on intercropping maize varieties Bisi 18 and soybean varieties Biosoy II obtain the highest value. This study recommends that the improvement of nitrogen and phosphorus status in climate change can be achieved by intercropping Bisi 18 corn and Biosoy II soybeans in the dryland of North Lombok.

1. Introduction

Maize is one of the second most important commodities after rice, both as a source of food and animal feed. Increasing the rate of growth of the population, need for food, and reduced land farming due to over function of land for the benefit of non-agricultural as well as climate changes, encourage various ways of manipulation of plants and the environment. The pattern of planting intercropping is one of the solutions to increase productivity. The system of intercropping is more advantageous than the system of monoculture because the productivity of the land becomes high, the commodity that is produced is also diverse, and the risk of failure can be minimized [1]. Some plants can be intercropped with maize and one of them is crop soybeans. The intercropping pattern with legumes can improve the level of fertility

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of the soil through the fixation of nitrogen in legumes [2][3]. Generally, people do a double-cropping pattern in cultivation, even though doing several kinds of intercropping planting patterns can result in increased production [4]. The production of shelled maize in an intercropping pattern of 1: 3 between maize and soybeans is 3.5 tonnes per ha [5]. The intercropping of 3: 3 rows of mycorrhizal inoculated maize and soybean accompanied by the addition of cow manure 12 tonnes per ha could increase soil N and P nutrient status, increase plant nutrient uptake (N and P), development of arbuscular mycorrhizae (MA) in soil and crop yields [6]. Inoculation with seed coating with indigenous mycorrhizae can increase growth, plant production, plant N, P uptake, and nutrient availability in maize-sorghum cropping patterns in the dryland of North Lombok [7]. Application packages inorganic fertilizer mixed fertilizer, organic fertilizer, and mycorrhizal biofertilizers can also improve the nutrient status, nutrient uptake, growth, and yield of maize in dryland [8].

Some of the lands may be used as an alternative to address the needs of food such as dryland that can be planted in the season of rain, but there is a problem that is not the availability of water and soil nutrients. The problem can be solved with the techniques of cultivation intercropping on dryland that will result in climate micro- that differ from cultivation on the land of rice fields. The arrangement of cropping patterns in intercropping aims to create a microclimate in plants [9]. The system of planting will affect the density of the population of plants which causes competition needs of life among individuals, to create a climate that is typical in the population of plants is often called climate micro.

Plants are complex and sensitive to the effects of climate change [10]. Climatic conditions will affect growth and productivity. Without the element of climate micro, the growth of the plants will be retained even though some plants can adjust themselves to stay alive. Besides that there are problems of others on crops of maize which needs the element nitrogen is a lot compared to soybeans in the dryland. Because it is, the use of several varieties of maize and soybeans are planted with the system of intercropping is intended to determine the varieties are adaptive to the system of cultivation on the dryland. The research is aimed at studying the nutrient concentration of nitrogen and phosphorus on intercropping several varieties of maize and soybean in dryland North Lombok.

2. Materials and method

2.1. Experimental design

The research was conducted from May to August 2020 in the village of Akar Akar District of Bayan North Lombok. Observation of mycorrhizal populations and soil analysis was carried out at the Microbiology Laboratory and Soil Chemistry Laboratory, Faculty of Agriculture, Mataram University. The tools used are oven, scale, binocular microscope, magnetic stirrer, beaker, beaker, tweezers, multilevel filter, centrifuge, funnel, Petri, shovel, hoe, sickle, hand counter, raffia rope, plastic bag, tissue, label paper, filter paper, and stationery. The materials used were seeds of 5 varieties of maize and 5 varieties of soybean methylene blue, 10% KOH, glycerol, sucrose, and aquadest distilled water.

The experimental design used was a randomized block design (RBD) with 5 varieties of maize and soybeans planted with an intercropping system of 3 rows of maize: 3 rows of soybean. Each treatment was repeated 3 times to obtain 15 experimental plots, namely, V1 = NK212 Maize: Biosoy I, V2 = Bima Maize 20 URI: Dega I Soy, V3 = NASA 29 Maize: Detap Soybean, V4 = Bisi Maize 18: Biosoy Soybean II, V5 = Srikandi Kuning Maize: Anjasmoro Soybean [11].

2.2. Plants cultivation

Soil tillage was done using a tractor to remove the weeds from the land. The land was then divided into 15 plots of 5 m × 4.5 m size. The soil characteristics, a composite sample of 200 g, were taken [12]. Indigenous mycorrhizal inoculum, Glomus mosseae (the MAA01 mycorrhizal isolate including the hyphae and the mycorrhizal spores) used propagation results of culture pots for three months with soil media and manure (1: 1) sterile with maize host plants. Mycorrhizae inoculation and organic matter from cattle manure (1 ton/ha and 15 tons/ha) for all maize and soybean plots were used as treatments simultaneously and placed under the seeds as much as 20 g per planting holes at a depth of 10 cm [13].

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At the time of planting, fertilization is carried out with cattle manure (a dose of 15 tons/ha) given to the planting hole (equivalent to 360 g per maize plant and 180 g per soybean plant). Inorganic fertilization for maize plants was done three times, namely at the age of 7 days after seeding (das), 21 das, and 28 das. Fertilization of maize given with a dose of 180 kg/ha Urea (equivalent to 4.3 g per plant) and NPK. Phonska (15:15:15) at a dose of 120 kg/ha (equivalent to 2.8 g per plant), which is 60% of the recommended dose and for soybean plants is given with 60 kg/ha Urea (equivalent 0.79 g per plant) and 120 kg/ha Phonska (equivalent 1.49 g per plant) fertilizer which is the best dose to increase growth, yield and uptake of N and P in the planting patterns of maize - sorghum and soybeans in the dryland of North Lombok. The first fertilization is done at 7 das with a dose of 60 kg/ha Urea and 60 kg/ha NPK. Phonska fertilizer. The second fertilization with Urea and Ponska fertilizer is given at 21 das a dose of 60 kg/ha. The third fertilizing with Urea fertilizer is given at a dose of 60 kg/ha at 28 das. For soybean, Urea, and Phonska fertilizers are given at 1/3 dose at the age of 7 das, and the remaining 2/3 are given at 28 DAS. NPK fertilizer was applied in a 5 cm groove beside a row of maize and soybean plants at a depth of 5-7 cm before being covered with soil [14].

2.3. Plants protection and weeding

Plant protection was done by spraying OrgaNeem (an organic pesticide of plant origin containing Azadirachtin extracted from neem leaves) at a concentration of 5 mL OrgaNeem per Liter of water. Weeding is done at intervals of 10 days until the plants are 40 das by cleaning the growing weeds.

2.4. Observation of parameters

Parameters that were observed in this study, namely, the concentration of N, P, organic C content and pH of the soil at 40 das and 92 das, uptake of N and P per plant at 40 das [15, 16, 17]. Soil and plant samples were taken by systematic random sampling of 5 sample plants per plot.

2.5. Statistical analysis

Data were analyzed using two-way ANOVA and Tukey's HSD (Honestly Significant Difference) means-tested at a 5% level of significance

3. Results and discussion

3.1. Soil nutrient concentration

The results of research on soil nutrient concentrations and plant nutrient uptake are presented in Table 1. Table 1 shows the intercropping treatment of Bisi 18 maize: Biosoy II soybeans gave the highest yield and was significantly different when compared to other treatments at nutrient concentrations of N, P C- organic of the maize and soybeans at the age of 40 and 92 das and the soil pH of the maize at the age of 40 and 92 das. However, it was not significantly different in the soil pH of soybeans at the age of 40 and 92 das.

Table 1 shows that the total N nutrient concentration values in maize aged 40 and 92 das are 0.36% and 0.64%. The concentration of P available in the soil is 9.6 ppm and 9.87 ppm. The C-organic content was 14.57 g kg^{-1} and 15.9 g kg^{-1} and pH values were 6.97 and 7. The total N nutrient concentration values in soybeans aged 40 and 92 das were 0.33% and 0, 69%. At a concentration of P, available soil is 9.62 ppm and 9.88 ppm. The C-organic content was 12.41 g kg^{-1} and 12.94 g kg^{-1} and soil pH values were 6.99 and 7.

The availability of N in the soil is related to the process of fixation and denitrification of N elements [18]. Nitrogen fixation is carried out with the help of soil microorganisms and is carried out in 2 ways, namely symbiotic (R*hizobia* and *Frankia* sp) and non-symbiotic (*Azotobacter* and *Azotomonas*). In Table 1. the alleged increase in the element N in the soil is the result of high symbiotic fixation of element N due to soybean plants associated with *Rhizobium spp*. Symbiotic N_2 embedding provides a 10x greater amount of N than non-symbiotic N_2 embedding [19].

Table 1. Mean concentration of N, P, C-organic, and pH soil on maize and soybean intercropping variety at 40 das and 92 das.

	Variety (Maize & Soybean)	Total N (%)		Available P (ppm)		C-organic (g/kg)		pH	
		Maize	Soybean	Maize	Soybean	Maize	Soybean	Maize	Soybean
40 das	V1 (NK212 & Biosoy I)	0.32^{bc}	0.29^{c}	9.18^{b}	9.54^{c}	13.02^{d}	11.03^{e}	6.90^{b}	6.90^{a}
	V2 (Bima 20 URI&Dega I)	0.31^{c}	0.31^{b}	9.16^{c}	9.53^{d}	13.22^{c}	11.15^{d}	6.90^{b}	6.83^{a}
	V3 (NASA 29 & Detap)	0.33^{b}	0.29^{c}	9.14^{e}	9.55^{b}	13.22^{c}	11.24^{c}	6.90^{b}	6.90^{a}
	V4 (Bisi 18 & Biosoy II)	0.36^{a}	0.33^{a}	9.60^{a}	9.62^{a}	14.57^{a}	12.41^{a}	6.97^{a}	6.99^{a}
	V5 (Srikandi&Anjasmoro)	0.32^{bc}	0.29^{c}	9.15^{d}	9.53^{d}	13.65^{b}	11.54^{b}	6.99^{a}	6.96^{a}
	HSD 5%	0.010	0.017	0.008	8.767	0.038	0.015	0.030	3.021
92 das	V1 (NK212 & Biosoy I)	0.43^{c}	0.62^{c}	9.67^{d}	9.38^{b}	13.78^{e}	11.74^{e}	6.74^{d}	6.97^{ab}
	V2 (Bima 20 URI&Dega I)	0.45^{b}	0.62^{c}	9.65^{c}	9.36^{b}	14.42^{d}	11.85^{d}	6.95^{bc}	6.95^{b}
	V3 (NASA 29 & Detap)	0.42^{c}	0.62^{c}	9.68^{b}	9.30^{b}	14.56^{c}	12.36^{c}	6.93^{c}	6.99^{ab}
	V4 (Bisi 18 & Biosoy II)	0.64^{a}	0.69^{a}	9.87^{a}	9.88^{a}	15.90^{a}	12.94^{a}	7.00^{a}	7.00^{a}
	V5 (Srikandi &Anjasmoro)	0.37^{d}	0.64^{b}	9.67^{b}	9.36^{b}	15.56^{b}	12.54^{b}	6.97^{ab}	6.99^{ab}
	HSD 5%	0.010	0.011	0.010	0.098	0.035	0.017	0.038	0.037

Mean values in each column followed by the same letters are not significantly different between treatments of an intercropping variety.

The increase in P elements in this study can be triggered by a symbiotic interaction between plants and arbuscular mycorrhizae in the added mycorrhizal biofertilizer [20]. With the high percentage of root colonization and the number of spores it is known that phosphorus is a nutrient that is very difficult to move in the soil. The main role of arbuscular mycorrhizae is to provide phosphorus to plant roots via phosphate transporters present in the membrane of hyphae [21]. Arbuscular mycorrhizal fungi can hydrolyze organic phosphate in the soil and provide soluble phosphate to plants [22]. This fact is in line with the research of Astiko et al in 2019 showing that the nutrient status in the treatment of the intercropping pattern of 3 rows of maize and 3 rows of soybeans made a positive and significant contribution to increasing the nutrient status of N and P soil compared to the treatment of monoculture maize and soybeans [23].

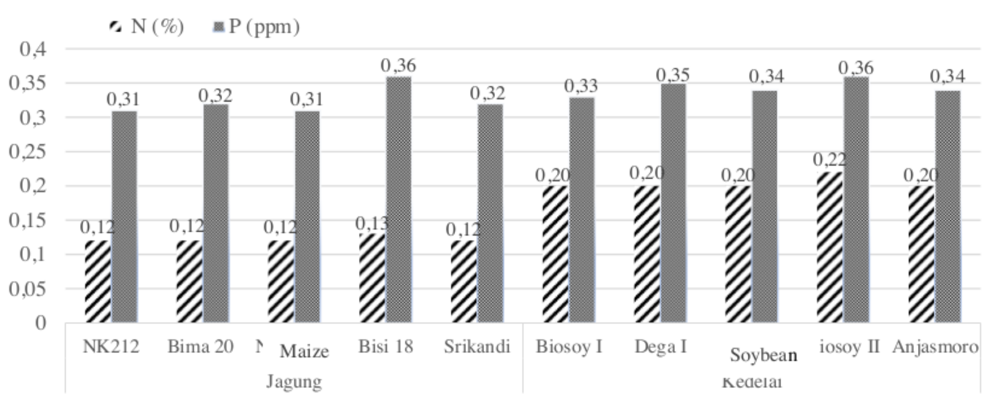

Figure 1. Mean N and P concentration in plant tissues on maize and soybean intercropping variety at 40 das.

Bisi 18 maize variety and Biosoy II soybean variety planted with an intercropping system significantly affected the N, P content, and soil plant tissue compared to the treatment of other varieties. In maize and soybean plants aged 40 das, the nutrient content of N and P soil and maize plant tissue varieties Bisi 18 and soybean Biosoy II were significantly different from the treatment of other varieties. The same condition occurs when maize and soybeans are 92 das. The system of intercropping maize varieties Bisi 18 and soybean varieties Biosoy II can improve uptake of N and P plants, but not the case with other varieties of maize and soybeans. The Bisi 18 maize variety is the most suitable maize variety for intercropping with the Biosoy II variety of soybeans. This shows that there is functional compatibility between the two varieties that can create optimal conditions to help plants increase soil nutrient availability and nutrient uptake by plants so that it will also increase plant metabolism and biosynthesis so that crop production in both varieties is more optimal, compared to other varieties [24][25].

3.2. Nutrient concentration in plant tissues

In Figure 1, uptake of N and P nutrients in the intercropping treatment of Bisi 18: soybean Biosoy II gave the highest value and was significantly different in the nutrient uptake of P maize, N, and P of soybeans at the age of 40 das. However, there was no significant difference in the N nutrient uptake of maize at the age of 40 das. The absorption values of N and P nutrients for maize plants are 0.13% and 0.36%, for soybean plants are 0.22 ppm and 0.36 ppm.

The relationship between organic C is very closely related to the total N in the soil. C-organic acts as a source of energy for microorganisms in the soil. one of them is a microorganism that plays a role in breaking down nutrients. Increased mineralization of organic matter in the soil of this research area can be a factor in the high content of C-organic and total N in the soil. Also, the soil pH ranging from 6.5 to 7.5 provides optimal nutrient availability. The activity of soil microorganisms (soil microorganisms) is also affected by the magnitude of the soil pH value [26]. The absorption of nutrients by the plants associated with some movement of water and nutrients to the cell surface roots that the mass flow root interception, and diffusion [27]. These three mechanisms directly determine the total nutrient uptake of N and P available in plants. The need for essential nutrients is needed at the beginning of growth to stimulate overall growth.

The N_2-binding bacteria present in soybean plants can convert N_2 to ammonia (NH_3). Ammonia is then metabolized by N-binding bacteria and plants into protein as one of the constituents of its body. Plant diversity largely determines the N cycle [28]. Types of intercropped plant varieties can affect the total N uptake due to the utilization of resources in a synergistic or competitive. If the nutrients obtained from sources available are different (space, time, and form are different) then the uptake of N total by the plant will be increased so that the chances of the occurrence of leaching are small [29]. Plant soybean is a plant that is not in too much need of N [30]. Plants which different content of N it will have biomass dry with the content of N is different so the time and type of microbe that is necessary for the process of decomposition is also going to be different so that at the end affect the cycle N [31].

4. Conclusion and suggestions

The impact of climate change is the occurrence of a shift in the nutrient concentration of N, P, C-organic content and pH in the soil at 40 or 92 das and the uptake of N and P nutrients in the plants at 40 das on intercropping maize varieties Bisi 18 and soybean varieties Biosoy II obtain the highest value. This study recommends that the improvement of nitrogen and phosphorus status in climate change can be achieved by intercropping Bisi 18 corn and Biosoy II soybeans in the dry land of North Lombok.

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References

[1] Ceunfin S, Prajitno D, Suryanto P and Putra E T S 2017 *J. Pertanian Konservasi Lahan Kering* **2** 3

[2] Lihtourgidis A S, Dorgas C A, Damalas C A and Vlachostergios D N 2011 *Journal of Crop Science* **5** 396

[3] Leki W, Lelang M A, and Taolin R I C O 2015 *Jurnal Pertanian Konservasi Lahan Kering Savana Cendana* **1** 17

[4] Rifai A, Basuki S dan Utomo B 2014 *Widyariset* **17** 59

[5] Aminah I S, Rosmiah and Yahya M H 2014 *J. Lahan Suboptimal* **3** 62

[6] Astiko W, Ernawati N M L and Silabawa I 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **637** 012005

[7] Astiko W, Wangiyana W and Susilowati, L E 2019 *Journal of Tropical Agricultural Science* **42** 1131

[8] Astiko W, Rohyadi A, Windarningsih M and Muthahanas I 2021a *Prosiding Saintek LPPM Universitas Mataram* **3** 103

[9] Wentasari R and Sesanti R N 2016 *J. Penelit. Pertan. Terap.* **16** 94

[10] Indrawan R R, Suryanto A, Soelistyono R 2017 *J. Prod. Tan.* **5** 92

[11] Gomez, Kwanchai A and Arturo A Gomez 1984 *Statistical procedures for agricultural research* (New York, USA: John Wiley & Sons)

[12] Soil Survey Staff 2014 *Keys to soil taxonomy* (USA: USDA) pp 327

[13] Astiko W, Fauzi M T and Sukartono 2016 *Nusantara Bioscience* **8** 66

[14] Astiko W, Fauzi M T and Sukartono 2016a *Journal of Tropical Soils* **20** 119

[15] Page, Albert Lee, Robert H Miller and Dennis R Keeney 1982 *Methods of soil analysis* (USA: American Society of Agronomy)

[16] Lisle L, Gaudron J and Lefory R 1991 *Laboratory techniques for plant and soil analysis* (Armidale, NSW, Australia: Department of Agronomy and Soil Science, University of New England)

[17] Bray, Roger H and Kurtz L T 1945 *Soil Science* **59** 39

[18] Stern W R 1993 *Field crops research* **34** 335

[19] Finan T M, Wood J M and Jordan D C 1983 *Journal of Bacteriology* **154** 1403

[20] Abbasi H, Akhtar A and Sharf R 2015 *American Journal of Plant Nutrition and Fertilization Technology* **5** 40

[21] Jakobsen I, Smith S E and Smith F A 2003 *Mycorrhizal ecology* (Berlin, Heidelberg: Springer) pp 75-92

[22] Jagnaseni B, Aveek S, Babita S and Siraj D 2016 *Resonance* **21** 1093

[23] Astiko W, Wangiyana W and Susilowati, L E 2019 *Journal of Tropical Agricultural Science* **42** 1131

[24] Ofori F and Stern W 1987 *Advances in Agronomy* **41** 41–90

[25] Bulson H A J, Snaydon R W and Stopes C E 1997 *Journal of Agricultural Science* **128** 59

[26] Geisseler D and Scow K M 2014 *Soil Biology and Biochemistry* **75** 54

[27] Bassirirad H 2000 *New Phytologist* **147** 155

[28] Oelman Y and Wilcke W 2004 *Geophysical Research Abstracts* **6** 5406

[29] Hooper D U and Vitousek P M 1997 *Science* **277** 1302

[30] Schröder J J, Neeteson J J, Oenema O and Struik P C 2000 *Field Crops Research* **66** 151

[31] Wedin D and Pastor J 1993 *Oecologia* **84** 433

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