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# Effect of Intercropping on Mycorrhizal Populations, Growth, and Yield on Several Varieties of Maize (*Zea mays* L.) and Soybeans [*Glycine max* (L.) Merr.] in Dryland North Lombok, Indonesia

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**Abstract.** Drylands plays an important role to increase agricultural production. In addition, it also contributes to land use efficiency. The intercropping system provides a solution to increase agriculture productivity in dryland. The objective of this research was to determine the mycorrhizal population, growth, and crop yield of several maize and soybean varieties grown in the field using an intercropping system. The methodology conducted in this study involved 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 treatments were repeated three times to obtain 15 experimental plots. The results showed that the mycorrhizal population, growth, and yield of Bisi 18 maize intercropping and Biosoy II soybean varieties obtained the highest value. Mycorrhizal population, wet and dry biomass weight of root, shoots, yield, the highest was obtained in the intercropping of maize varieties Bisi 18/soybean variety Biosoy II. The highest yield was given by the intercropping of maize varieties Bisi 18 and soybean varieties Biosoy II with maize dry seed grain weight 7.4 tons/ha and a soybean dry seed grain weight of 0.94 tons/ha.

## 1. Introduction

Dry land in Indonesia is a potential land when viewed from the existing area. The total area of dry land in Indonesia is 148 million ha, but only about 76.22 million ha are suitable for agricultural cultivation. In Nusa Tenggara Barat (NTB), dry land is a future comparative advantage, because 84% (1.8 million hectares) of the area is dry land that has the potential to be developed into productive agricultural land [1]. The potential of dry land in North Lombok is around 38,000 hectares and of that area only 30% is used for productive agriculture for food crops such as corn and cassava [2].

North Lombok Regency has a climate of type D3-D4 with 3 or 4 wet months and 7-9 dry months [3]. The soil surface characteristics are sandy loam texture (55% sand and 9% clay) with a pH approximately 5.97 and has low soil organic carbon (0.89%) with low nutrient status (0.13% N, 23.60 mg kg<sup>-1</sup> extractable P and 0.57 cmol kg<sup>-1</sup> K exchangeable) [4]. The low quality of soil fertility is a biophysical



limiting factor which is still considered responsible for the low production of food crops in the dry lands of North Lombok [5].

One way to improve land efficiency is through intercropping cropping patterns because it optimizes the use of light, water and nutrients, controls weeds, pests and diseases, improves soil fertility through N fixation from legumes and is a pathway to sustainable agriculture [6]. Soybean and corn plants allow intercropping because maize plants require high nitrogen, while soybeans can fix nitrogen from free air so that the nitrogen deficiency in maize is also met by excess nitrogen in soybeans [7]. The selection of the right soybean and maize varieties and in accordance with the conditions of the land to be used as an intercropping area will determine the amount of crop productivity [8].

The intercropping pattern which consists of 3:3 rows of corn and soybeans respectively, which each are inoculated with MA with addition of cow manure (12 tons/ha) has shown improvement in soil N and P nutrient status [9]. Inoculation with seed coating with indigenous mycorrhizae can increase growth, crop production, plant N, P uptake and nutrient availability in maize-sorghum cropping patterns in dry lands of North Lombok [10]. The application of a fertilizer package of a mixture of inorganic fertilizers, organic fertilizers and mycorrhizal biological fertilizers can also improve nutrient status, nutrient uptake, growth and yield of corn plants in dry land [11]. However, the extent of mycorrhizal development, growth and yield of intercropping several varieties of maize and soybean in dry land has not been widely reported

## 2. Materials and method

### 2.1. Design of the Experimental

The method used in this research that the experimental method was conducted from May to August 2020 in the village of Akar Akar District of Bayan North Lombok. The analyses of mycorrhizal populations and soil nutrients were conducted at the Microbiology Laboratory and Soil Chemistry Laboratory, Faculty of Agriculture, Mataram University.

The experimental design used was a randomized block design (RBD) with 5 varieties of maize and soybeans planted with an intercropping system of 3 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 = Yellow Srikandi Maize: Anjasmoro Soybean [12].

### 2.2. Conduct of Experiments

Soil tillage process was conducted using a tractor in order to remove unwanted weeds from the experimental land. The experimental land was then divided into 15 plots (5 m × 4.5 m). Indigenous mycorrhizal inoculum, *Glomus mosseae*. (the M<sub>AA01</sub> 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. The inoculation of Mycorrhizae 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].

The planting and fertilization process was carried out simultaneously. This was then followed by addition of cattle manure (a dose of 15 tons/ha) which was given to the planting hole (equivalent to 360 g per maize plant and 180 g per soybean plant). Inorganic fertilization for maize plants was conducted at least three times. The chosen times were 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 dry land of North Lombok. The first fertilization was conducted at 7 das with a dose of 60 kg/ha Urea and 60 kg/ha NPK. Phonska fertilizer. The second fertilization with Urea and Phonska 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 [13].

### 2.3. Observation of Parameters

Parameters that observed in this study, namely, the number of mycorrhizal spores per plant, percentage of root colonization per plant [14]; [15]; [16]; [17], shoot wet weight and maize-soybean root per plant, dry weight maize-soybean shoot and roots per plant, harvested dry stover weight and sun-dried stover per plot, the weight of harvested cobs and pods, the weight of cobs and dry pods in the sun, the weight of maize shelled and soybean shelled per plot, the weight of 1000 seeds.

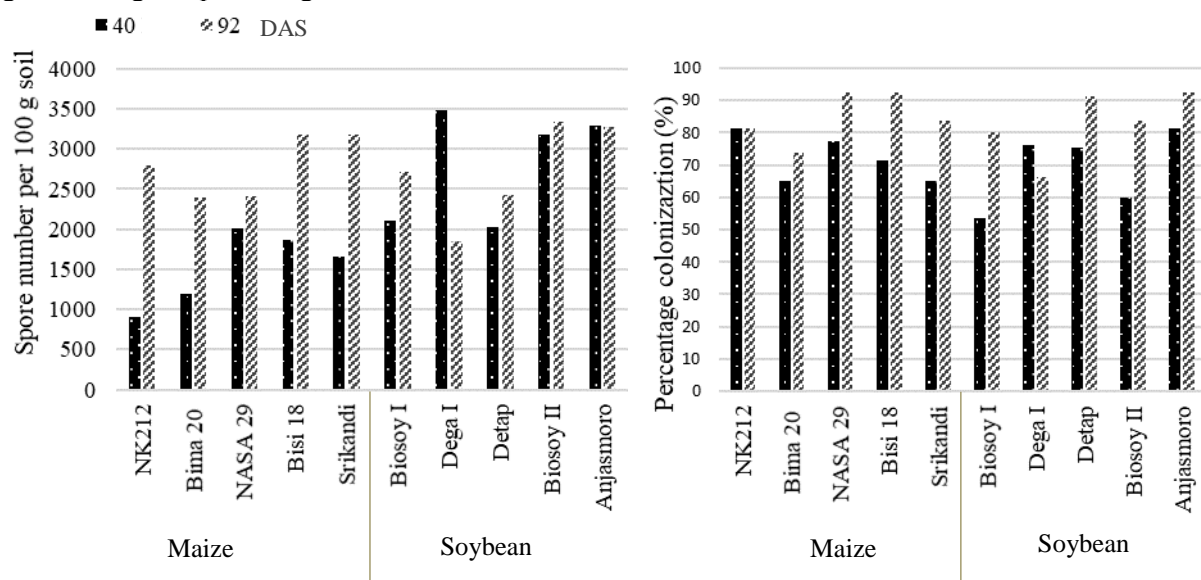
### 2.4. Data Analysis

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

## 3. Results and discussion

### 3.1. Development of Mycorrhiza

The number of spores and the percentage of colonization in Figure 1 shows that at the age of 40 DAS, the number of maize spores in the intercropping treatment of NASA 29 maize: soybean Detap was significantly higher and different from other intercropping treatments. On the number of spores of soybean, the highest result was found in maize intercropped treatments Bima 20 URI: Dega I. At the age of 92 DAS treatment of intercropped maize Bisi 18: Soybean Biosoy II gives the highest yield in the second crop. In the percentage of root colonization at the age of 40 DAS, the intercropping treatment of NK212 maize: Biosoy I soybeans gave the highest percentage for maize, while for soybean plants, Srikandi Kuning maize intercropping treatment: Anjasmoro soybeans produced the highest percentage. At the age of 92 das, the intercropping treatment of Bisi 18 maize: Biosoy II soybeans gave the highest percentage of maize, while the Srikandi Kuning maize intercropping soybean plant: Anjasmoro soybean gave the highest percentage.



**Figure 1.** Mean spore number (spores per 100 g soil) and percentage colonization rates (%-colonization) on maize and soybean intercropping variety at 40 and 92 das.

The density of the number of arbuscular mycorrhizal spores determines the percentage level of root colonies and the percentage of root colonies indicating the level of suitability between mycorrhizal species and plant root systems. The results of the data obtained indicated that there were differences in the density of the number of spores and the percentage level of root colonies in each intercropping

treatment of several varieties. mycorrhizal spores have different characteristics and compatibility between each species with the character of plant roots. mycorrhizal spores whose genetic characteristics match the exudate excreted by the plant root system will be stimulated to germinate [18].

### 3.2. Biomass Weight and Yield

Table 1 shows the results of wet biomass is the highest weight on the roots of maize plants at the age of 40 das contained in maize intercropping treatment NASA 29: Soybean Detap, at the age of 92 das results in the highest yield from the treatment of maize intercropped treatments Bima 20 URI: soybean Dega I. In part plant shoot at 40 das Srikandi Kuning maize intercropping treatment: Anjasmoro soybeans gave the highest yield but at 92 das the treatment of Bima maize intercropping 20 URI: Dega I soybean was the highest compared to other treatments. The highest yield of wet biomass weight of soybean plants at the roots at the age of 40 das was found in the intercropping treatment of NASA 29: Detap soybeans, at the age of 92 das the highest yield was from the intercropping treatment of Bisi 18: soybean Biosoy II. In the shoot section, Srikandi Kuning maize intercropping with Anjasmoro soybean was highest at 40 and 92 das.

**Table 1.** Wet and dry biomass weight (g/plant) of maize and soybean for each treatment of intercropping Variety on 40 and 92 das.

Variety (Maize & Soybean)	Maize				Soybean			
	Root		Shoot		Root		Shoot	
	40 das	92 das	40 das	92 das	40 das	92 das	40 das	92 das
<b>Wet biomass weight</b>								
V1 (NK212 & Biosoy I)	25.90 <sup>b</sup>	34.22 <sup>b</sup>	141.50 <sup>c</sup>	260.00 <sup>b</sup>	2.17 <sup>c</sup>	1.89 <sup>c</sup>	22.25 <sup>b</sup>	41.62 <sup>a</sup>
V2 (Bima 20 URI&Dega I)	32.01 <sup>ab</sup>	74.87 <sup>a</sup>	138.00 <sup>c</sup>	449.50 <sup>a</sup>	3.20 <sup>bc</sup>	2.84 <sup>bc</sup>	18.98 <sup>b</sup>	58.33 <sup>a</sup>
V3 (NASA 29 & Detap)	43.95 <sup>a</sup>	42.35 <sup>b</sup>	234.50 <sup>b</sup>	428.50 <sup>a</sup>	5.29 <sup>a</sup>	3.37 <sup>b</sup>	48.04 <sup>a</sup>	47.93 <sup>a</sup>
V4 (Bisi 18 & Biosoy II)	43.70 <sup>a</sup>	35.23 <sup>b</sup>	225.00 <sup>b</sup>	375.50 <sup>ab</sup>	4.25 <sup>ab</sup>	4.97 <sup>a</sup>	40.00 <sup>ab</sup>	63.44 <sup>a</sup>
V5 (Srikandi & Anjasmoro)	31.25 <sup>ab</sup>	38.95 <sup>b</sup>	330.00 <sup>a</sup>	386.00 <sup>ab</sup>	3.03 <sup>bc</sup>	2.83 <sup>bc</sup>	53.35 <sup>a</sup>	70.10 <sup>a</sup>
HSD 5%	73.62	152.14	13.32	17.55	22.23	31.34	1.18	1.04
<b>Dry biomass weight</b>								
V1 (NK212 & Biosoy I)	10.37 <sup>bc</sup>	10.09 <sup>b</sup>	38.73 <sup>c</sup>	48.00 <sup>c</sup>	0.72 <sup>a</sup>	0.85 <sup>c</sup>	4.25 <sup>b</sup>	8.21 <sup>ab</sup>
V2 (Bima 20 URI&Dega I)	13.32 <sup>abc</sup>	44.97 <sup>a</sup>	31.35 <sup>c</sup>	94.70 <sup>a</sup>	1.11 <sup>a</sup>	1.82 <sup>ab</sup>	4.69 <sup>b</sup>	9.45 <sup>ab</sup>
V3 (NASA 29 & Detap)	16.61 <sup>a</sup>	20.82 <sup>b</sup>	74.72 <sup>b</sup>	71.38 <sup>b</sup>	0.91 <sup>a</sup>	1.38 <sup>bc</sup>	10.97 <sup>a</sup>	6.84 <sup>b</sup>
V4 (Bisi 18 & Biosoy II)	14.31 <sup>ab</sup>	15.97 <sup>b</sup>	87.82 <sup>a</sup>	65.88 <sup>c</sup>	1.18 <sup>a</sup>	1.18 <sup>bc</sup>	8.41 <sup>ab</sup>	9.86 <sup>ab</sup>
V5 (Srikandi & Anjasmoro)	10.06 <sup>c</sup>	21.79 <sup>b</sup>	140.22 <sup>b</sup>	71.00 <sup>b</sup>	1.13 <sup>a</sup>	2.15 <sup>a</sup>	11.68 <sup>a</sup>	12.52 <sup>a</sup>
HSD 5%	35.70	16.08	4.16	10.58	4.31	4.73	0.94	0.74

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

The results of this biomass weight analysis indicate that the intercropping of several varieties of maize and soybeans used in this study caused differences in plant growth rates. Plant growth is strongly influenced by genetic factors (varieties) and location agroecology such as water and soil fertility. The contribution of arbuscular mycorrhizal fungi in sustainable maintenance of plant health and soil fertility very significant [19]. Cultivation, variety, and climate management are factors that determine the variety of wet biomass production of maize produced. Apart from the variety factor that causes diversity, it is also suspected that the availability of sufficient nutrients is due to the improved concentration of N and P nutrients in the intercropping pattern of maize and soybeans. Also, direct N transfer from soybean to maize triggers roots and shoot growth in the intercropping pattern [20].

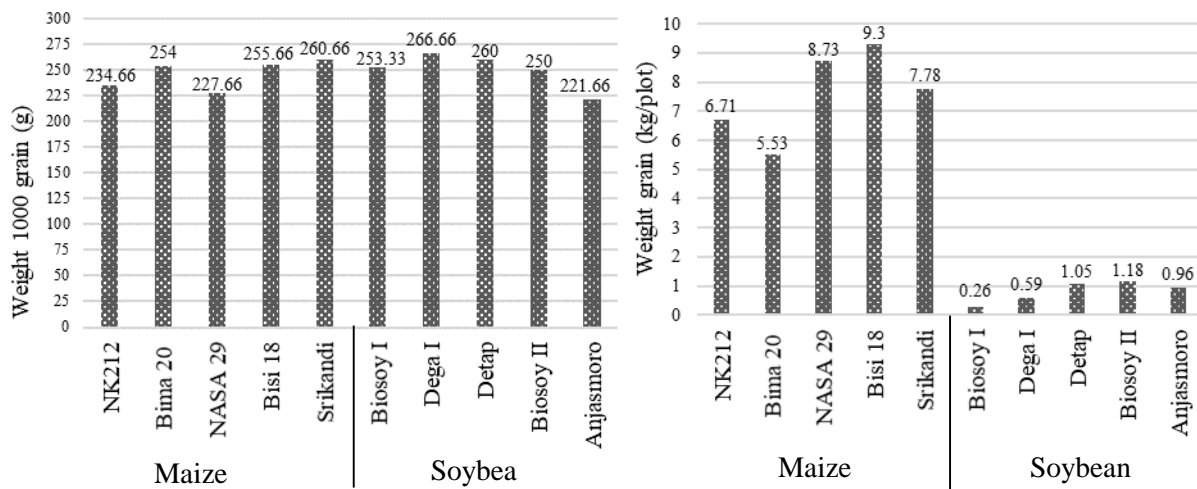
**Table 2.** Weight Shoot per Plot (kg/plot), Weight Cob per plot and weight Pods per Plot (kg/plot), Weight Cob Maize and Weight Pods Soybean per plant (g/plant) on 92 das.

Variety (Maize & soybean)	Maize			Soybean		
	WS (kg/plot)	WCt (g/plant)	WCp (kg/plot)	WS (kg/plot)	WPt (g/plant)	WPP (kg/plot)
Harvest dry weight						
V1 (NK212 & Biosoy I)	21.8 <sup>b</sup>	165.75 <sup>a</sup>	13.60 <sup>b</sup>	2.46 <sup>c</sup>	16.98 <sup>b</sup>	0.68 <sup>c</sup>
V2 (Bima 20 URI&Dega I)	29.4 <sup>a</sup>	193.00 <sup>a</sup>	12.60 <sup>b</sup>	3.40 <sup>bc</sup>	31.97 <sup>ab</sup>	1.95 <sup>ab</sup>
V3 (NASA 29 & Detap)	23.13 <sup>b</sup>	172.47 <sup>a</sup>	16.73 <sup>a</sup>	4.26 <sup>ab</sup>	29.60 <sup>b</sup>	1.68 <sup>ab</sup>
V4 (Bisi 18 & Biosoy II)	29.00 <sup>a</sup>	148.94 <sup>a</sup>	17.46 <sup>a</sup>	5.10 <sup>a</sup>	35.22 <sup>a</sup>	2.22 <sup>a</sup>
V5 (Srikandi & Anjasmoro)	22.66 <sup>b</sup>	156.40 <sup>a</sup>	13.93 <sup>b</sup>	4.20 <sup>ab</sup>	46.35 <sup>a</sup>	1.44 <sup>b</sup>
BNT 5%	3.64	65.41	2.54	1.46	18.04	0.69
Dry weight yield						
V1 (NK212 & Biosoy I)	16.20 <sup>b</sup>	125.00 <sup>a</sup>	8.86 <sup>c</sup>	0.79 <sup>b</sup>	5.79 <sup>b</sup>	0.46 <sup>c</sup>
V2 (Bima 20 URI&Dega I)	20.46 <sup>a</sup>	150.00 <sup>a</sup>	7.60 <sup>c</sup>	0.94 <sup>ab</sup>	15.12 <sup>ab</sup>	1.15 <sup>b</sup>
V3 (NASA 29 & Detap)	18.20 <sup>ab</sup>	140.00 <sup>a</sup>	11.70 <sup>ab</sup>	0.96 <sup>ab</sup>	17.60 <sup>a</sup>	1.60 <sup>ab</sup>
V4 (Bisi 18 & Biosoy II)	19.40 <sup>ab</sup>	100.00 <sup>a</sup>	13.11 <sup>a</sup>	1.20 <sup>a</sup>	18.32 <sup>a</sup>	1.88 <sup>a</sup>
V5 (Srikandi & Anjasmoro)	19.66 <sup>ab</sup>	117.66 <sup>a</sup>	10.90 <sup>b</sup>	1.05 <sup>ab</sup>	24.96 <sup>a</sup>	1.27 <sup>b</sup>
BNT 5%	3.81	65.427	1.73	0.35	10.14	0.46

Mean values in each column followed by the same letters are not significantly different between treatments of intercropping variety; WS (Weight Shoot Per plot); WCt (Weight Cob Per plant); WCp (Weight Cob Per plot); WPt (Weight Pods Per plant); WPP (Weight Pods Per plot)

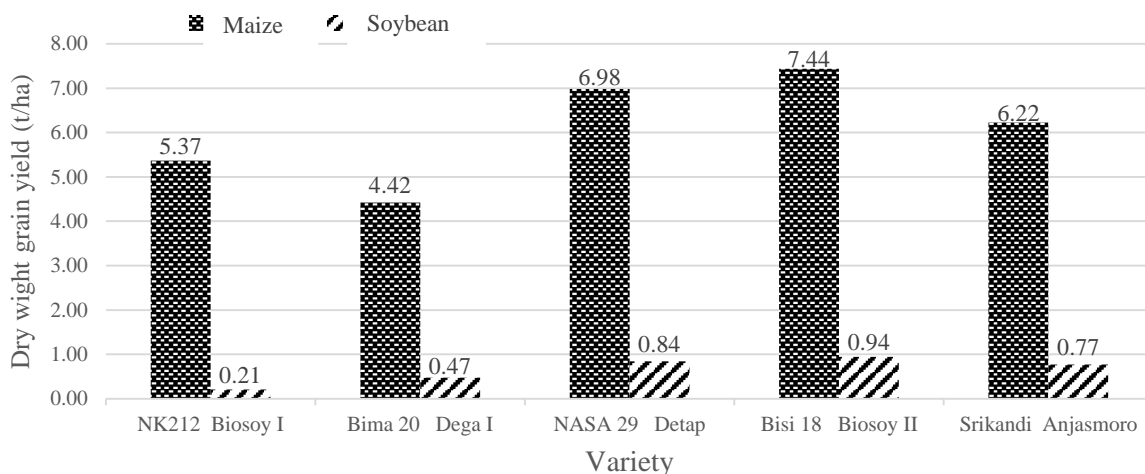
Table 2 shows that in maize, the highest yield of the dry weight of harvest stover per plot and harvest dry weight of cobs per plant is found in the intercropping treatment of Bima 20 URI: Dega I soybeans. On the dry weight of harvested cobs per plot, intercropping treatment of maize Bisi 18: soybeans Biosoy II gave the highest yield. For soybean, the highest yield of the dry weight of stover harvest per plot and dry weight of pod per plot was found in the intercropping treatment of Bisi 18: Biosoy II soybean. And on the dry weight of harvested pods per plant, the intercropping treatment of Srikandi Kuning maize: Anjasmoro soybeans gave the highest yield.

The different weights of cobs and pods were thought to be due to the diversity of each variety in producing photosynthate. The ability of each cultivar to reduce CO<sub>2</sub> and convert carbohydrates is one of the factors that determine the ability of plants to produce photosynthate through the photosynthesis process [21]. Cultivars that provide the highest photosynthate partition to the leaves will have the potential to give high yields because the leaves are the main recipients of light for the photosynthesis process [22]. The variation between different plants and different cultivars in light interception, photosynthetic efficiency, power of storage (sink), and harvest index affect the actual yield. Besides, the improved uptake of N and P nutrients and the availability of good nutrients from nutrient concentration data in the soil provide sufficient nutrients for plants to produce high stover and weight of cobs and pods [23].



**Figure 2.** Weight grain yield (kg/plot) and wight dry 1000 grain (g) treatments of intercropping variety on 92 das.

From Figure 2, it can be seen that the highest weight of 1000 grains of maize was obtained by the intercropping treatment of Srikandi Kuning maize: Anjasmoro soybeans, while at the weight of 1000 soybeans, the intercropping treatment for NASA 29: Detap soybeans gave the highest yield. The weight of the shelled seeds of the Bisi 18: soybean intercropping treatment Biosoy II gave the highest yield on the weight of maize and soybeans.



**Figure 3.** Dry weight grain yield treatments of intercropping variety per ha.

Based on Figure 3, intercropping of maize varieties Bisi 18 and soybean Biosoy II gave the highest yields with shelled maize weight of 7.4 ton/ha and soybean shelled weight of 0.94 ton/ha. The weight factor of 1000 seeds and shelled weight are thought to be influenced by genetic factors related to the ability of plants to optimize production in regulating seed filling by allocating photosynthetic products appropriately [24]. The high weight value of 1000 grains could be caused by the moisture content of the seeds [25]. Besides, the weight value of 1000 grains can be caused by the content of food reserves (photosynthetic pile of food) contained in the seeds where at the time of cooking the physiology of the ability to use food reserves will be maximum. The yield potential of a maize variety is determined by



four components, namely the number of cobs, number of seeds per row, the weight of 1000 grains, and productivity [26].

The ability of plants to produce seeds is thought to be influenced by the P nutrient absorbed by plants. The P element can increase the protein content and seed weight which in turn will affect plant yields. large seed size gives a high total dry seed yield [27]. This is in line with the increase in the number of available P nutrients in the soil and P uptake in maize and soybean plants [28]. Besides, the symbiosis between mycorrhizae and intercropped plants is thought to increase P uptake from the hydrolysis of organic phosphate in the soil and provide soluble phosphate to plants through phosphate transfer through hyphal membranes [29].

#### 4. Conclusion and suggestions

The result show that mycorrhizal populations in the soil in the intercropping of maize varieties Bisi 18 and Soybean varieties Biosoy II at the age of 40 and 92 DAS showed the highest values. Growth in intercropping maize varieties Bisi 18 and Soybean varieties Biosoy II showed the highest value. Intercropping of maize varieties Bisi 18 and soybean Biosoy II gave the highest yields with shelled maize weight of 7.4 tons/ha and soybean shelled weights of 0.94 tons/ha.

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## **CERTIFICATE**

This certificate is proudly awarded to

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as  
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of the paper entitled:

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