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Yields of Fruit, Seeds, and Forage those Harvested From Intercropping of Sorghum (*Sorghum bicolor* [L.] Moench) and Bean (*Phaseolus vulgaris* L.)

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Abstract. The limited availability of agricultural land had forced farmers switch from solecropping to intercropping. The purpose of this study was to determine the yield of bean fruit, bean and sorghum seeds, and sorghum forages harvested from sorghum-bean intercropping compare to those from solecropping. The research was carried out on the agricultural land of the Vegetable Seed Center in Sekincau District, West Lampung Regency, Lampung Province at 05°02'27" South Latitude and 104°18'16" East Longitude and at the altitude of 1173.1 m from sea level, during April to August 2021. Two varieties of bean, Balitsa-2 was dwarf bean and Horti-3 was climbing bean, were respectively planted intercoppingly with sorghum of Numbu variety. As comparators were solecroppings of Balitsa-2 bean, Horti-3 bean, and Numbu sorghum. The single factor treatment was applied in a randomized complete block design with six blocks as six repliclates. yield of sorghum seeds and yields of sorghum forages harvested from the sorghum-bean intercropping were lower than those harvested from solecropping. The yield of bean fruits and bean seeds harvested from the sorghum and dwarf bean inter-cropping did not differ from those harvested from the sole-cropping, but the seed yield harvested from the climbing and sorghum inter-cropping was lower than those of its mono-cropping.

INTRODUCTION

Sorghum (*Soghum bicolor* [L.] Moench) that has been developed by various countries[1] for feed, food, and bioethanol was using solecropping or monoculture system. Because of the limited area, it has also to be able to develop by using intercropping technique, mainly with the highland horticultural crops such as beans. Sorghum is a cereal from the C4 metabolic plant group[2,3] which is well adapted to high levels of CO_2 and high temperature[4] were very suitable for cultivation in the tropics[5] like Indonesia and in the current global warming era. In the lowlands, the productivity of sorghum intercropping with various crops has been proved, such as with soybean[6,7], peanuts[8], cassava[9,10,11,12,13]. So, it is necessary to study the performance of the Indonesian sorghum superior variety of Numbu in the highlands area in the intercropping with beans.

In Indonesia, beans are planted using sole cropping technique in highland areas which are 400 m from sea level (FSL) or more to meet the increasing consumer demand[14]. Indonesian superior beans varieties, both dwarf and climbing types, are sequencially capable of producing up to 21 and 30 tons/ha of fresh fruit[15]. The beans are reported to be able to produce well in intercropping systems with various crops, such as tomato[16], ginger[17], pakcoi (*Brassica rapachinensi*)[18], red chili, onions and chilie pepper[19], sweet corn[20], and mustard green[21]. Intercropping of bean with sorghum has not been reported but it is expected to be compatible, because sorghum morphologically is similar to

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maize. Intercropping of bean and sweet corn in the highland of ± 1054 m FSL showed a land equivalence ratio (LER) of 1.47[20]. When sorghum planted in intercropping with the bean in the highlands is succeeded and it can produce well and does not interfere with the productivity of the beans, then this intercropping system will be able to increase the yields and income of bean farmers[22,23,24,25,26,27,28,29]. Intercropping it on bean that grow faster in the seedling phase, sorghum can experience a lack of light. As a C4 metabolism plant, the lack of light can greatly reduce its growth rate and yield [30,31,32,33,34]. The decrease in nitrate reductase activity[35] in plants that lack of light was an indicator of low carbon fixation by light, the response of which varies between genotypes[36].

Developing of sorghum in the highlands is not possible with monoculture cultivation given the limited land area. Intercropping with bean by applicating a specific cultivation technique that do not reduce the bean productivity have to be found. By applying cultivation techniques reported by Pramono[7,13], namely combining two kinds of crops exactly, giving fertilizer dose fully to each kind of crop, and applying east-west row planting direction; and by of reducing sorghum population up to 50% of the intercropping, the bean productivity of bean and sorghum intercropping will not decrease. It will make LER more than one. This study aimed to determine the fruit and seeds productivity of bean; seed and forage of sorghum, and the LER of the bean-sorghum intercropping.

METHODS

Place and Time of the Experiment

This experiment was conducted at the Horticulture Parent Seed Center located in Sekincau District, West Lampung Regency, Lampung Province, 05°02'27" SL and 104°18'16" EL at an altitude of 1173.1 m FSL, Sekincau Village, Sekincau District, West Lampung Regency, Indonesia (Figure 1) and the Laboratory of Seed and Plant Breeding, Faculty of Agriculture, University of Lampung during May – October 2021.

Research Implementation

The soil was plowed twice, then loosened using a rotating harrow, and then made beds or mounds (Figure 2). The bottom width of the bed was 100 cm for monoculture sorghum and 80 cm for monoculture bean and intercropping with sorghum. The height of the bed was 15 cm. The distance between mounds were a) 40 cm for bean monoculture (s_1 and s_2), b) 60 cm for monoculture sorghum (s_3), and c) alternating 40 cm and 70 cm for dwarf bean and sorghum intercropping (s_4) and also for climbing bean and sorghum intercropping (s_5) (Figure 2). Each bed was covered with black-silver plastic mulch.

FIGURE 1. The experimental location in Sekincau Village, Sekincau District, West Lampung Regency, Lampung Province, Indonesia with the elevation of ±1173.1 m from sea level (red color and arrow)[37].

Planting distance of bean and sorghum were shown in Figure 2. For climbing bean, there were two rows per bed, the planting distance within row was 25 cm and between the row was 60 cm. For dwarf bean, there were three rows per bed, the planting distance in the edge two rows was 25 cm and in the middle row was 50 cm, and between the rows was 30 cm. The planting distance of monoculture sorghum was 25 cm within the row, 80 cm between the rows, and there were two rows per bed. The sorghum rows in the bean-sorghum intercropping were placed at right and left of every two beds of the bean. So that, these intercropping pattern were named a symmetrical intercropping pattern of

141-141 for the climbing bean and sorghum intercropping and a symmetrical intercroppingg pattern of 161-161 for dwarf bean and sorghum intercropping (Figure 2). Two grains of bean seeds and 4-6 grains of sorghum seeds were planted in every planting hole (PH) with planting depth of 3-5 cm and then covered with soil. In the bean and sorghum intercropping, the sorghum seeds were placed 5 cm from the row of planting holes of bean seeds (Figure 2). After sorghum seedlings already came through the soil surface, the number of sorghum plants per hole was reduced and only two plants were left.

The chicken manure organic fertilizers was given 136 g per planting hole for the dwarf bean, the climbing bean, and sorghum. Inorganic fertilizer NPK 16:16:16 of 12 g per planting hole was given to dwarf bean and climbing bean, respectively. This dose was given in two times. The first application was 3 g per PH that was given in liquid form of 3 g per 200 mL that poured into every PH of bean of 21 days old. The second application was 9 g of granular NPK per PH that were burried into soil 10 cm from every the PH and given in the form of granular. The NPK fertilizer of 10 g per PH given to sorghum was applied in two times. The first application was 3 g per PH in liquid form pouring into the PH at the plant age of one month. The second application was 7 g per PH in granular form that placed at 10 cm from the PH at the plant age of two months.

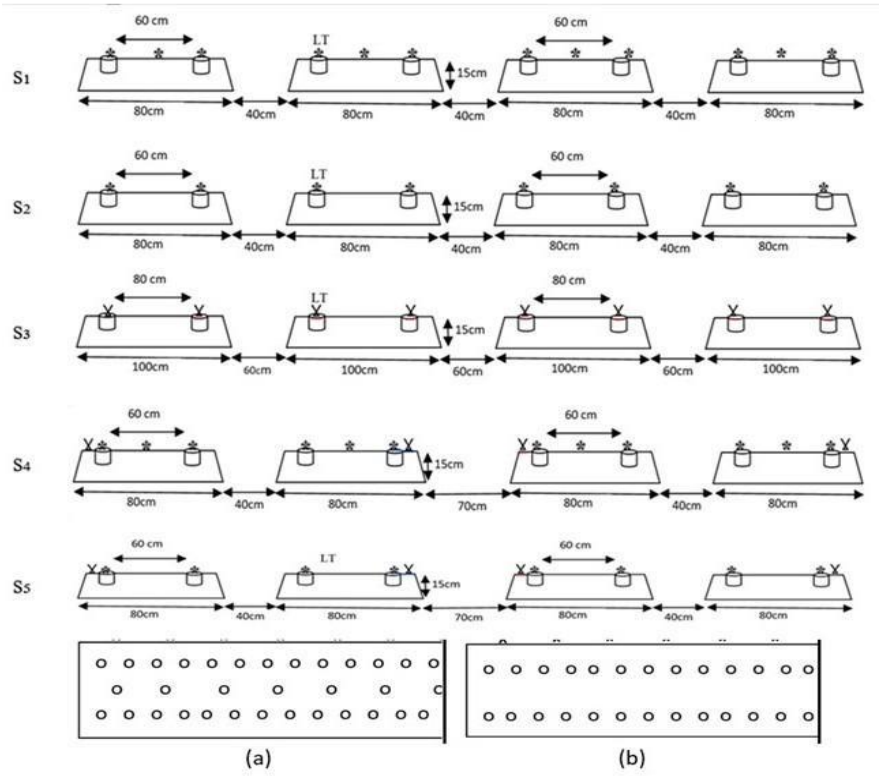

FIGURE 2. Beds, planting holes (PH), intercropping pattern, and planting distance of a) monoculture of dwarf-bean Balitsa-2 (s_1), b) monoculture of climbing-bean Horti-3 (s_2), monoculture of Numbu sorghum (s_3), d) intercropping of dwarf bean and sorghum Numbu (s_4), and e) intercropping of Horti-3 climbing bean and sorghum Numbu (s_5) viewed horizontally from the end of beds; rows of Balitsa-2 (a) and Horti-3 (b) bean in the beds; * = bean crops, Y = sorghum crops; LT = planting holes

Experimental Design and Data Analysis

This experiment used single factor treatment in a randomized complete block design with six blocks as six replicates. The single treatment was in the form of a cropping system consisting of 5 levels, namely a) monoculture of Balitsa-2 dwarf bean (s_1), b) monoculture of Horti-3 climbing bean (s_2), c) monoculture of Numbu sorghum (s_3), d) intercropping of sorghum-Balitsa-2 dwarf bean (s_4), and e) intercropping of sorghum- Horti-3 climbing bean (s_5). The number of experimental unit was 30 plots. Each plot was 6 m x 6 m containing 4 beds. Crop population of sorghum and bean in each plot were presented in Table 1. The population of dwarf bean and climbing bean were full (100%)

in the monoculture or in the intercropping plots. Whereas, the population of sorghum crop in the monoculture was full (100%) and in the intercropping of bean and sorghum was half of monoculture (50%).

TABLE 1. Crop population based on planting holes number per experimental plot of 36 m² for monoculture of dwarf bean (s_1), climbing bean (s_2), sorghum (s_3), and for intercropping of dwarf bean and sorghum (s_4), and climbing bean and sorghum (s_5)

Crops	M			TS	
	s_1	s_2	s_3	s_4	s_5
Sorghum	0	0	146	73	73
Dwarf bean of Balitsa-2	180	0	0	0	180
Climbing bean of Horti-3	0	146	0	146	0

Data analysis used were 1) the Bartlett's test to see the homogeneity of variance between treatments, 2) the Tukey's test to see the non-additivity of observational data, 3) the Fisher's test of analysis of variance to see the simultaneous effect of treatments, 4) the orthogonal comparison test to see the difference treatment mean between monoculture and intercropping, and 5) the t-Students test to see that the value of LER >1.

The variables measured were 1) productivity of sorghum and bean seeds, 2) productivity of fresh pod of beans or bean fruits, and 3) productivity of sorghum forage. The LER value was calculated based on these productions with the formula $LER = YI_1/YM_1 + YI_2/YM_2$; YI_1 = yield of the first crop in the intercropping, YI_2 = yield of the second crop in the intercropping, YM_1 = yield of the first crop in the monoculture, and YM_2 = yield of the second crop in the monoculture. The yield of bean fruits was harvested from 3 beds per plot of 27 m². The productivity of bean seeds was harvested from 1 beds per plot of 9 m². Seed and forage yield of sorghum were harvested from a plot of 36 m² containing 4 beds.

RESULTS AND DISCUSSION

The summary of orthogonal contrast analyses the effects of cropping systems for the yield of a) bean fruit and seeds were presented in Table 2, and b) sorghum seeds and forage were presented in Table 3. Table 2 showed there were not difference fruit and seed yields, both on dwarf and climbing beans between those harvested from monoculture and those harvested from intercropping. Table 3 showed that there were a highly significant difference ($P<0.01$) in the yields of sorghum seeds and sorghum forage those harvested at 75, 84, and 123 days after planting (DAP) between those harvested from monoculture and from the intercropping with the bean. Also, there was difference sorghum seed and forage yield those harvested from intercropping with dwarf beans and those harvested from intercropping with climbing bean.

TABLE 2. The F-test values of orthogonal contrast for fruits and seeds those harvested from the monocultures (M) of dwarf bean (s_1), of climbing bean (s_2), the intercroppings (IC) of dwarf bean and sorghum (s_4); and of climbing bean and sorghum (s_5)

Variable	M *vs* IC	M	IC
	$s_1 + s_2$ *VS* $s_4 + s_5$	s_1 *VS* s_2	s_4 *VS* s_5
Bean fruits (in kg/27 m²)	0,77NS	54,05**	67,53**
Bean seeds (in kg/9 m²)	0,53NS	54,80**	92,20**

Note: NS was nonsignificant cause F-test < F-table 0,05 = 4,54; ** was highly significant cause F-test > F-table 0,01 = 8,68.

TABLE 3. The F-test values of orthogonal contrast for sorghum seeds and forage harvested from monokulture (s_3) (M), the intercropping (IC) with dwarf bean (s_4), and from the intercropping with climbing bean (s_5)

Variabel	M *vs* IC	IC
	s_3 *VS* $s_4 + s_5$	s_4 *VS* s_5
Sorghum seeds (kg/36 m²)	245,69**	72,39**
Forage 75 DAP (kg/36 m²)	35,06**	6,69*
Forage 84 DAP (kg/36 m²)	45,39**	11,57**
Forage 123 DAP (kg/36 m²)	43,92**	5,11*

Notes: DAP=days after planting, and ** was highly significant cause F-test > F-table 0,01 = 8,68 and * was significance cause F-test > F-tabel 0,05 = 4,54.

Yield of bean fruits

The yield of dwarf bean fruits per plots of 27 m² harvested from the monoculture (26.69 kg/plot) did not differ from those harvested from the intercropping with sorghum (26.93 kg/plot) (Figure 3). Likewise, the yield of climbing bean fruits harvested form monoculture (49.39 kg/plot) did not differ from those harvested from the intercropping with sorghum (53.84 kg/ plot). The average of bean fruit yield of climbing bean (51.60 kg/plot) was higher than those of dwarf bean (26.8 kg/plot). This difference in fruit yields was caused by different varieties.

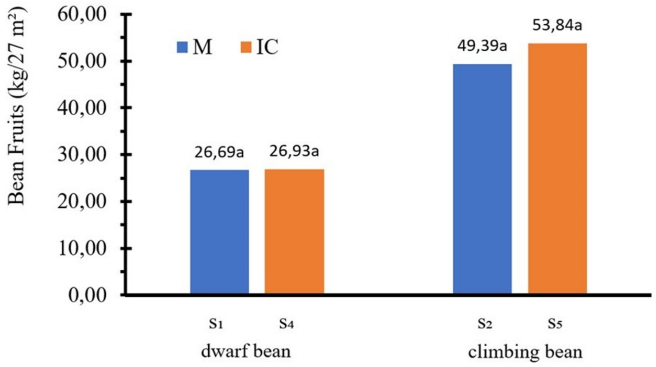

FIGURE 3. The yields of dwarf bean fruits harvested from monoculture (s_1) compare to those from intercropping (s_4) and climbing beans fruits harvested from the monoculture (s_2) compare to those from intercropping (s_5). Two numbers in dwarf bean or in climbing bean followed by the same letter do not significantly differ according to orthogonal contrast test at P ≤0,05.

Yield of Bean Seed

The yield of dwarf bean seeds per plot of 9 m² harvested from the monoculture (1.15 kg/plot) did not differ from those harvested from the intercropping with sorghum (1.12 kg/plot) (Figure 4). Likewise, the yield of climbing bean seeds harvested from the monoculture (3.19 kg/plot) was higher than those harvested from the intercropping (1.87 kg/plot). The average yield of climbing bean seeds (2.53 kg/plot) was higher than dwarf bean seeds (1.13 kg per plot). This difference in seed yields was also caused by different varieties.

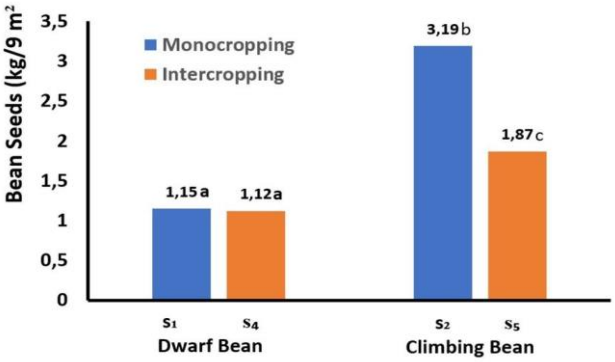

FIGURE 4. The yileds of dwarf bean seeds harvested from monoculture (s_1) compare to those from intercropping (s_4) and climbing beans seeds harvested from the monoculture (s_2) compare to those from intercropping (s_5). Two numbers in dwarf bean or in climbing bean followed by the same letter do not significantly differ according to orthogonal contrast test at P ≤ 0,05.

Yield of Sorghum Seed

Sorghum seed yield per plot of 36 m² harvested from the monoculture (13.86 kg/plot) was higher than those harvested from the dwarf bean –sorghum intercropping (4.54 kg/plot) and was higher than those harvested from the climbing bean - sorgum intercropping (2.76 kg/plot) (Figure 5). The yield of sorghum seeds harvested from the inter-cropping with dwarf bean (4.54 kg/plot) was 62.5% lower than that harvested from monoculture of 13.86 kg/plot. The

yield of sorghum seeds harvested from the inter-cropping with climbing bean, 2.76 kg/plot, was 80.1% lower than that harvested from monoculture of 13.86 kg/plot (Figure 5).

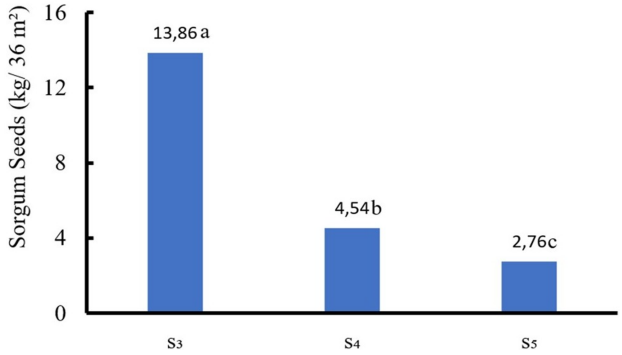

FIGURE 5. The yield of sorghum seeds harvested from the monoculture (s_3), from the dwarf bean-sorghum intercropping (s_4), and from the climbing beans-sorghum intercropping (s_5). Two numbers followed by the same letter do not significantly differ according to orthogonal contrast test at P<0,05.

Yield of Sorghum Forage Harvested at 75 Days After Planting (DAP)

The yields of sorghum forage per plot of 36 m² that harvested at 75 DAP from monoculture was 106.50 kg/plot, that from the intercropping with dwarf bean was 29,83 kg/plot, and from the intercropping with climbing bean was 15,5 kg/plot (Figure 6). Forage yields of sorghum harvested from the inter-cropping of dwarf bean and sorghum and the inter-cropping of climbing beans and sorghum were lower than those harvested from monoculture, 71.7% and 85.4%, respectively.

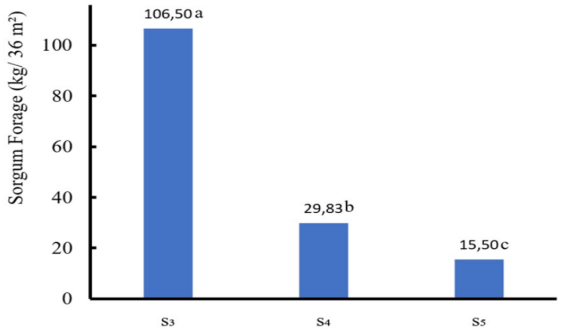

FIGURE 6. The yield of sorghum forage that harvested at 75 DAP from monoculture (s_3), from the intercropping with dwarf bean (s_4), and from the intercropping with climbing bean (s_5). Two numbers followed by the same letter do not significantly differ according to orthogonal contrast test at P<0,05.

Yield of Sorghum Forage Harvested at 84 DAP

The yield of sorghum forage per plot of 36 m² harvested at 84 DAP from monoculture was 136.74 kg/plot, from the intercropping with dwarf bean was 42,09 kg/plot, and from the intercropping with climbing bean was 23,15 kg/plot (Figure 7). Forage yields of sorghum harvested from the dwarf bean and sorghum intercropping (s_4) was 69,1% lower than those harvested from monoculture and that harvested from the intercropping of climbing bean and sorghum was 83,1% lower than those from monoculture.

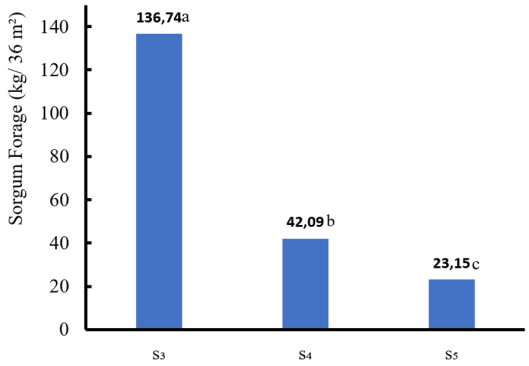

FIGURE 7. The yield of sorghum forage that harvested at 84 DAP from the monoculture (s_3) and from the intercropping with dwarf bean (s_4) and with climbing bean (s_5). Two numbers followed by the same letter do not significantly differ according to orthogonal contrast test at P<0,05.

Yield of Sorghum Forage Harvested at 123 DAP

The yield of sorghum forage per plot of 36 m² harvested at 123 days after planting (DAP) from the monoculture was 90,12 kg/plot. It was 73,0% higher than those harvested from the intercropping with dwarf bean 24.33 kg/plot, and 82.6% higher than those harvested from the intercropping with climbing bean 15,65 kg/plot (Figure 8).

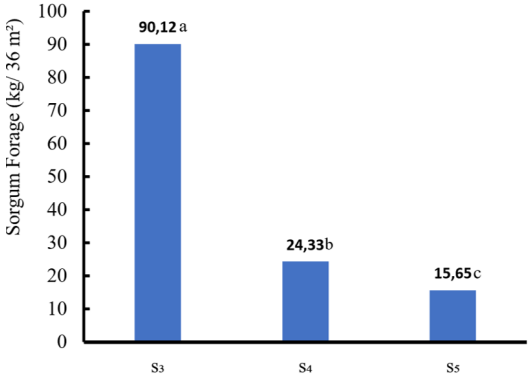

FIGURE 8. The yield of sorghum forage that harvested at 123 DAP from the monoculture (s_3) and from the intercropping with dwarf bean (s_4) and with climbing bean (s_5). Two numbers followed by the same letter do not significantly differ according to orthogonal contrast test at P<0,05.

Land Equivalency Ratio (LER)

The LER of the bean-sorghum intercropping were calculated based on a) bean and sorghum seed yields, b) bean fruit and sorghum seed yields, c) sorghum forage and bean fruit yields as presented in Table 4. Based on bean seed (BS) and sorghum seed (SS) yields, the LER values of the dwarf bean and sorghum intercropping was 1,30 and of the climbing bean and sorghum inter-cropping was 0.79. The LER value of 1,30, according to the T-test, was higher than one. It means that the intercropping of dwarf bean and sorghum was effective and feasible for producing bean and sorghum seeds. On the other hand, the intercropping of climbing bean and sorghum was not effective and feasible for producing bean and sorghum seeds, bacause according to T-test the LER value 0,79 was less than one.

Based on bean fruit (BF) and sorghum seed (SS) yields, the LER values of the intercropping of dwarf bean and sorghum was 1.33 and of the climbing bean and sorghum intercropping was 1.29. T-test shows that these LER values were higher than one. It meant that these inter-cropping of bean and sorghum were effective and feasible for producing bean fruits and sorghum seeds. Based on yields of bean fruit (BF) and sorghum forage harvested at 75 DAF (SF75), the LERs of dwarf bean and sorghum intercropping was 1,28 and climbing bean and sorghum intercropping was 1,24. Based on bean fruit (BF) and sorghum forage harvested at 84 DAF (SF84) yields, the LER of dwarf bean and sorghum intercropping was 1,31 and climbing bean and sorghum intercropping was 1,26. Based on bean fruit (BF) and sorghum forage harvested at 123 DAF (SF123) yields, the LER of dwarf bean and sorghum intercropping was 1,27 and of climbing bean and sorghum intercropping was 1,26. The T-test values for all of these LER values were higher than T-table at the probability of 0.05 = 2.57, so these LER values were higher than one. It meant that the inter-cropping of

bean and sorghum was effective and feasible for producing bean fruits and sorghum forage. It was shown that the inter-cropping of dwarf bean and sorghum and climbing beans and sorghum were feasible to be developed in the highland area for producing bean fruits, bean seeds, sorghum seeds, and sorghum forage. The only one exception was the inter-cropping of climbing bean and sorghum that was not feasible for producing bean and sorghum seeds, because the LER value was less than one (NKL = 0,79).

TABLE 4. The land equivalency ratio (LER) in the intercropping of dwarf bean and sorgum (s_4) and climbing bean and sorghum (s_5) calculated based on the yields of sorghum seeds (SS), of bean seeds (BS), bean fruits (BF); and sorgum forage (SF)

Yields	s_1	s_2	s_3	s_4	s_5
Sorghum seeds (SS) (kg/36 m²)			13,86	4,54	2,76
Bean seeds (BS) (kg/9 m²)	1,15	3,19		1,12	1,87
Bean fruits (BF) (kg/9 m²)	26,69	49,39		26,63	53,84
Sorghum Forage (SF)					
Harvested at 75 DAP (SF75) (kg/36 m²)			106,50	29,83	15,50
Harvested at 84 DAP (SF84) (kg/36 m²)			136,74	42,09	23,15
Harvested at 123 DAP (SF123) (kg/36 m²) without panicle			90,12	24,33	15,65
Land Equivalency Ratio (LER)					
Based on BS and SS				1,30*	0,79*
T-test				2,68	2,65
Based on BF and SS				1,33*	1,29*
T-test				3,31	3,83
Based on BF and SF75				1,28*	1,24*
T-test				3,31	3,83
Based on BF and SF84				1,31*	1,26*
T-test				3,37	3,48
Based on BF and SF123				1,27**	1,26**
T-test				6,64	4,91

Notes: DAP = day after planting; * = significant according to T-test at level of P < 0,05; ** = highly significant according to T-test at level of P < 0,01; T-table at P=0,05 is 2,57 and at P=0,01 is 4.03; monocultures of dwarf bean (s_1), climbing bean (s_2), and sorghum (s_3); intercropping of dwarf bean and sorghum (s_4) and intercropping of climbing bean and sorghum (s_5).

The yield of bean fruits, both of dwarf bean and climbing bean, those harvested from monoculture did not differ from those harvested from intercropping with sorghum (Fig. 3). It meant that the environmental engineering applied to the bean-sorghum intercropping could minimize the competition of sorghum and bean. The results of this research answer the problems that backgrounding this research, because factually the worries of the growth and development of bean crop would be disturbed by sorghum planted together with them did not take place.

In the intercropping of climbing bean and sorghum, the lush of bean and sorghum leaves took place, mainly in sorghum rows which nearing by bean rows (Figure 9). The lushness of leaves made leaves in that area experienced lack of light. The low light caused the rate of photosynthesis low and photosynthesis yield produced by the leaves was low also. The low climbing bean seed yield that harvested from the intercropping with sorghum (Table 4) was the results of that phenomenon. The low seed yield of the intercropping of climbing bean and sorgum made the LER value of the intercropping decreased up to 0,79. Hence, the climbing bean and sorghum intercropping was not feasible for producing bean and sorghum seeds, but it was still feasible for producing bean fruit and sorghum forage.

The environmental engineering applied in this experiment was cultivation technique referred to those applied on inter-cropping sorghum with cassava[13]; namely a) fertilizing to each kind of crop in the intercropping with independent doses, b) implementing the inter-cropping on appropriate planting season for water sufficient, c) implementing the east-west rows direction, and d) reducing the population of the second crop, i.e. sorghum, to 50%[7]; was succeeded in minimizing the level of competition in the intercropping, especially to the bean as the main crop. By implementing these four cultivation techniques, the competition pressure between bean and sorghum in the bean and sorghum inter-

cropping could be minimized, so that the seeds and fruits yield of bean in the intercropping did not decrease, mainly in the intercropping of dwarf bean and sorghum.

FIGURE 9. The physical performances of crop stem age 6, 7, and 10 weeks after planting (WAP) causing the period of shading each other between climbing bean and sorghum (A, B, C) was longer than that of dwarf bean and sorghum (D, E, F) during crops growth and development in the inter-cropping

The yields of sorghum seeds and sorghum forage in the intercropping with dwarf and climbing beans experienced the decline. The yield of sorghum seeds declined by more thas 50%, namely 62.5% in the intercropping with dwarf bean and by 80.1% in the intercropping with climbing bean (Fig. 5). The yield of sorghum forage those harvested at the age of 75 DAP also declined more than 50%, namely 71.7% in the dwarf bean and sorghum intercropping and 85.4% in the climbing bean and sorghum intercropping (Fig. 6). The yield of sorghum forage those harvested at the age of 84 DAP declined 69,1% in the dwarf bean and sorghum intercropping and 83.1% in the climbing bean and sorghum intercropping (Fig. 7). The yield of sorghum forage those harvested at the age of 123 DAP declined 73.0% in the dwarf bean and sorghum intercropping and 82.6% in the climbing bean and sorghum intercropping (Fig. 8). The sorghum forage harvested at 123 DAP was without the panicle, so the yield was lower than that harvested at 84 DAP.

The decrease in sorghum seed yield of more than 50% was not only caused by the sorghum population in the intercropping with bean, which was 50% of the monoculture population, but there was the effect of intercropping itself also. The effect of intercropping was the reduction in light received by sorghum plants due to shade from bean crops. In the intercropping of bean and sorghum, the shade from bean crops to sorghum was becoming a kind of restricting factor on the growth of sorghum. The decline of sorghum seed and sorghum forage yields was strongly suspected as a result of the light lacks as mentioned by the former researchers[30],[31],[32],[33],[34]. In the intercropping of dwarf bean and sorghum, the effect of shading of 50 cm tall dwarf bean on sorghum growth ended at the sixth WAP (Fig. 9). In the inter-cropping of climbing bean and sorghum, the effect of bean shading on the growth and development of the sorghum crop took place since the first week to more than the tenth or even up to the end of twelve weeks (Figure 9), namely at the time the climbing bean crop was cut down. Then, growth of sorghum with the full light just begun at the thirteenth week up to harvest at the end of the fifteenth week. That was why the decline yield of sorghum seeds and sorghum forage those harvested from the intercropping with climbing bean was far higher than those harvested from the intercropping with dwarf bean (Fig. 5, 6, 7, and 8).

The LER of the intercropping of sorghum and bean was greater than one (LER>1) (Table 4). In general, the averages of LER of the dwarf bean and sorghum intercropping were higher, i.e. 1,30 (range 1.27-1.33) than the LER of the climbing bean and sorghum 1,26 (range 1,24-1,29). It meant that the intercropping of dwarf bean and sorghum and climbing bean and sorghum were effective and feasible to be implemented in highland areas. It was also mean that the intercropping patterns of the symmetrical of 1-6-1-1-6-1 for the intercropping of dwarf bean and sorghum and the symmetrical 1-4-1-1-4-1 for the intercropping of climbing bean and sorghum were effective and feasible for producing dwarf bean seeds, dwarf and climbing bean fruits, but not for producing sorghum and climbing seeds. The results of this intercropping pattern will support the Decree of the Minister of Agriculture of the Republic of Indonesia[38] in order to overcome the scarcity of land in producing seeds. These LER values were not too different from several previous reports, namely the LER of 1.47 in the intercropping of sweet corn and bean[20] and LER of 1.45

in the intercropping of sorghum and soybean Grobogan and LER of 1.44 in the intercropping of sorghum and soybean Argomulyo[7].

CONCLUSIONS

The yields of dwarf bean and climbing bean fruits harvested from the inter-cropping with sorghum did not differ to those harvested from the monoculture. The yield of dwarf bean seeds harvested from the inter-cropping with sorghum did not differ to those harvested from the monoculture, but the yield of climbing bean seeds harvested from the inter-cropping with sorghum was lower than those harvested from the monoculture. On the other hand, yields of sorghum seeds and sorghum forage harvested from the intercropping with bean experienced declines up to more than 50% compared to those harvested from monoculture. However, the LER of intercropping of beans and sorghum were more than one in producing seeds of dwarf bean and sorghum, fruits of dwarf bean or climbing bean and sorghum forage or sorghum seeds, except in producing climbing bean seed and sorghum seeds. In the future, the intercropping pattern between sorghum and climbing bean as well as dwarf bean needs to be studied more deeply to eliminate the decline in seed and forage yields per stem of sorghum crops.

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