Effect of crop proportion within cassava-soyabean double cropping on harvest seed of soyabean (*Glycine max* [L.]) and its viability

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Abstract. To increase the productivity of a land in producing cassava tubers and soyabean seeds can be done by intercropping both of them. The objective of this experiment was to assess the harvest and viability of soyabean seeds collected from various crop proportion of cassava-soyabean intercropping as compared to those collected from monocropping. A completely randomized block design (CRBD) was used with five blocks as five replications to arrange for treatment levels of crop proportion. The results showed that there were not different harvest and harvest components of soyabean seeds per plant, but there was a difference in harvest seed per m² among the crop proportion treatments. Also, the viability of soyabean seeds harvested from cassava-soyabean double cropping with different crop proportion did not differ.

Keywords: viability, seed, soyabean, yield.

1 Introduction

The crop proportion is the proportion composition of cassava-soyabean double cropping refers to the percentage of each crop relative to each sole cropping proportion. Planting soyabeans in double cropping with cassava can increase soyabean production in situations of land scarcity. In the cassava-soyabean double cropping, the high yield and the high viability of soyabean seeds can be reached by applying the exact cultivation method including applying the exact crop proportion both of them. High harvest of soyabean seed with high viability will support the national program in increasing soyabean production. The seed viability is the viability of seed in the post handling before storing. It is expected that seeds with high viability will have a high storage capacity.

The volume of Indonesian soyabean imports in 2023, which reached 2.58 million tons [1], is an opportunity to increase domestic soyabean production. With an average yield of 1.49 tons/ha, to reach 2.58 million tons, 1.73 million hectares of land and 86,500 tons of soyabean seeds or 50 kilograms/hectar [2] of seeds are needed. Since 2018, the Ministry of Agriculture of the RI has allowed the production of seeds using double cropping [3]. Indonesia's cassava land area reaches 628,305 hectares, which 157,202 hectares is in Lampung Province [4], which has high potential for increasing

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soyabean production using double cropping system. By applying appropriate cultivation techniques including adequate dosage of fertilizer, west-east of direction of rows, and reducing the proportion of each crop type in double cropping, it has been proven that competition can be minimized and does not reduce the yield of dwarf or climbing beans [5]. The yield of Numbu or UPCA sorghum seeds per plant harvested from double cropping with Argomulyo or Grobogan soyabeans was no different from that harvested from sole cropping of sorghum [6]. Sole cropping yielded more sorghum seeds per plant than double cropping with cassava [7].

The problem was in seed production using a cassava-soyabean double cropping system is how much harvest seed of soyabean and viability the soyabean seeds produced. Seed viability is the viability of seeds to produce normal sprouts [8] after seed processing before storage is very important for seed producers and users. The objective of this experiment was to know the harvest seed of soyabean and its viability that harvested from cassava-soyabean double cropping with various crop proportions.

2 Materials and methods

2.1 Location of the Experiment

The location experiment for seed production of soyabean using cassava-soyabean double cropping was carried out on the production land by the Main Seed Center of Vegetable (1,173 meters) in District of Sekincau, Regency of West Lampung, Lampung Province, Indonesia during June 2022 - March 2023. The viability of soyabean seed was observed in the Laboratoty of Seed and Plant Breeding the Faculty of Agriculture, University of Lampung, Bandar Lampung.

2.2 Material of Plant

This study involved the use of Dega-1 soyabean variety and Ketan waxy cassava clone. Dega-1 soyabean seeds were acquired from the Research Institute for Legume and Tuber Crops in Malang, East Java. The cassava clone of Ketan was gathered from farmers in Sekincau, West Lampung.

2.3 Experimental design and data analysis.

In this experiment, a completely randomized block design (CRBD) was used to arrange a single factor with four treatment levels, with five blocks representing five replications. Comparison of the mean values of crop proportion treatments was carried out using Duncan's multiple range test (DMRT) at the 5% level. Each of the four crop proportions was plotted on a 20 m^2 experimental plot. Table 1 showed crop proportion in the cassava(C)-soyabean(S) double cropping per plot of 20 m^2, spacing, and row arrangement. All crop proportions of double cropping (PCI) were created to increase efficiency of land use (ELU). The ELU was indicated by the value of planting areal equivalency (PAE) that calculated from the sum of the ratio of soyabean seed productivity in double cropping (SPD) and that in sole cropping (SPS) and the ratio of cassava productivity in double cropping (CPD) and that in sole cropping (CPS). So, the PAE =

SPD/SPS + CPD/CPS. The PAE was tested using the t-test statistic with 5% significant level compared to value of 1 (sole cropping). When PAE > 1 the ELU was suggested as efficient, but when PAE ≤ 1 the ELU was suggested not efficient. The PAE was also tested using the crop proportion ratio (CPR) value. The CPR value was the crop proportion of the double cropping, namely sum of percentages of soyabean and cassava populations in the double cropping. The crop proportion of cassava-soyabean double cropping applicated was good for soyabean and cassava growth and development when CPR = PAE.

Table 1. Crop proportions (CP) in the cassava(C)-soyabean(S) double cropping (DC) per plot of 20 m², spacing, and row arrangement.

CP (in %)	Cropping System	Spacing (m)		Row arrangement of cassava (C) and soyabean (S)
		Soyabean	Cassava	
100C+0S+	S	--	0.8 x0.6	CC
0C+100S	S	0.4x0.15	--	SS
97C+50S	DC	0.4x0.15+1.4x0.15	0.6x0.5+1.2x0.5	SS-CC-SS
97C+67S	DC	0.3x0.15+0.8x0.15	1.1x0.5	SS-C-SS
89C+67S	DC	0.4x0.15+0.8x0.15	1.2x0.45	SS-C-SS

2.4 Procedure of the Experiment

The land was cultivated using plow and harrow. Then, experimental plots of 5 m by 4 m were made. Seeds were used as the planting materials for soyabeans, and they were planted in depths of 3-5 cm, with 2-3 seeds per planting hole. For planting cassava, cutting stems 25 cm in size was used, and they were planted by inserting the base end into soil 5 cm deep. The planting of soyabeans and cassava was carried out at the same date with spacing and row arrangement as presented in Table 1.

To fertilize soyabean, 75 kilograms/hectar Urea, 100 kilograms/hectar SP-36, and 50 kilograms/hectar KCl were applicated twice. The one third doses of Urea (25 kilograms/hectar), full doses 100 kilograms/hectar of SP-36, and 50 kilograms/hectar of KCl were applicated as the first fertilizing when soyabean was two weeks after planting (WAP). Two third dose of 50 kilograms/hectar Urea was applicated as the second fertilizing when soyabean was 4 WAP. Using the path method, the fertilizers were sown into a shallow small ditch gutter that was specially prepared for them, 10 cm from the soyabean row, and then backfilled with soil.

To fertilize cassava, 200 kilograms/hectar Urea, 100 kilograms/hectar SP-36, and 100 kilograms/hectar KCl were applicated two times. Two fifth dose 80 kilograms/hectar of Urea, full dose 100 kilograms/hectar of SP-36, and full dose 100 kilograms/hectar of KCl were applicated as the first fertilizing when cassava was one month after planting (MAP), three fifth dose 120 kilograms/hectar of Urea was applicated as the second fertilizing at the time cassava was 3 MAP. Using the hole method, fertilizers were inserted into the shallow small holes prepared specially for them, located 10 cm from cassava stems, and then it backfilled with soil.

Good maintenance, weeding and controlling plant-disturbing organisms, is carried out until the soyabean pods were ripe. The harvesting soyabean pods that were yellow-brown in color carried at 92 days after planting (DAP). Then, pods were dried under the sun until the pods were fragile and releasing seeds from the pod could be done easily. Drying under the sun the soyabean seeds that had been threshed was continue carried up to 9-10% of moisture content. The yield and viability of the soyabean seeds were then observed by weighting, and testing them. The viability was measured via the germination test. The roll paper test was used to conduct the germination test according to the rule of ISTA. The cassava tuber harvest was the harvesting tubers at 8 WAP.

2.5 Observation and measurement.

Variables that used to measure soya bean harvest seed comprised of total pod numbers per plant, filled pod numbers per plant, hollow pod numbers per plant, seed numbers per plant, seed weight per plant, seed weight per meter², and seed 100 weights.. Variables that used to measure viability of soyabean seed comprisedof percent of normal sprout, germination speed, percent of strong normal sprout, and dry weight of normal sprout. The planting areal equivalency (PAE) was used to determine the efficiency of land use (ELU) of the double cropping.

3 Results and discussions

3.1 Results of data analysis

Results of data analysis showed that a) variance among treatments mean of all variable observed were homogenous according to Bartlett Test (P> 0,05), b) data of all variable observed were linear additive model according to Tukey's Test of Non-additivity (P>0,05), and c) the effect of crop proportion on all observed variables were not significant according to analysis of variance (P>0,05), except the variable of seed weight per m2 (P<0,01).

3.2 Soyabean Harvest seeds and Quality

The soyabean yield per plant was not affected by the crop proportions used in cassava-soyabean double cropping (50S+97C, 67S+97C, 67S+89C, and 100S+0C) (Fig. 1), except for soyabean harvest seed per m2 (Fig. 2). The different harvest seeds occurred between those harvested from sole cropping that were 0C+100S (164.0 g/m2) and double cropping that were 97C+50S (87,00 g/m2) and 97C+67S (114.0 g/m2) and 67S+89C (115.5 g/m2). Harvest seed harvested from the double cropping with lower soyabean population of 50S+97C was lower (87.0 g/m²) than those harvested from higher soyabean population of 67S+97C (114.0 g/m²) and 67S+89C (115.5 g/m²) (Fig. 2). The different treatment of crop proportions in cassava-soyabean double cropping, namely 97C+50S, 97C+67S, and 89C+67S, did not cause the differences of soyabean seed harvest per plant. Hence, It could be suggested that there was not competition effect occurred in the double cropping cassava-soyabean.

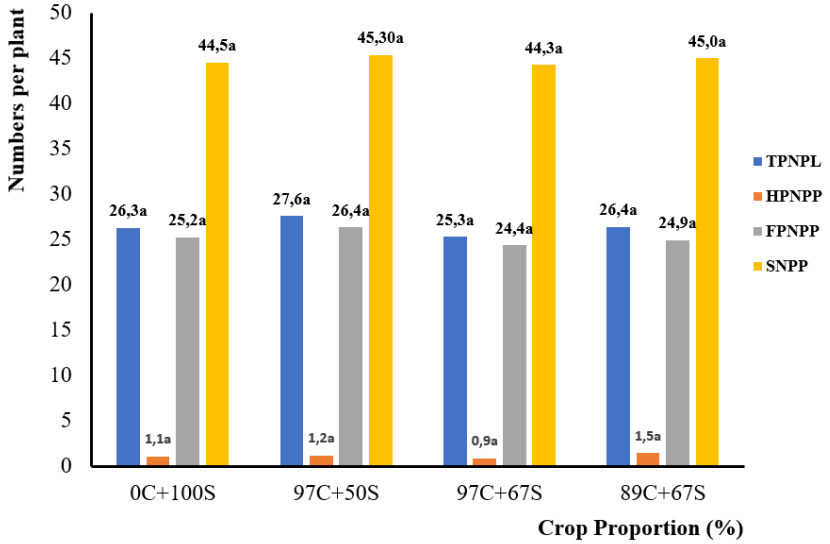

Fig. 1. Total pod numbers per plant (TPNPP), empty pod numbers per plant (EPNPP), filled pod numbers per plant (FPNPP), and seed numbers per plant (SNPP) that harvested from different crop proportion of cassava(C)-soyabean(S) double cropping. According to the DMRT test at 5% level, the crop proportion treatment did not cause differences in the average numbers of harvest seed.

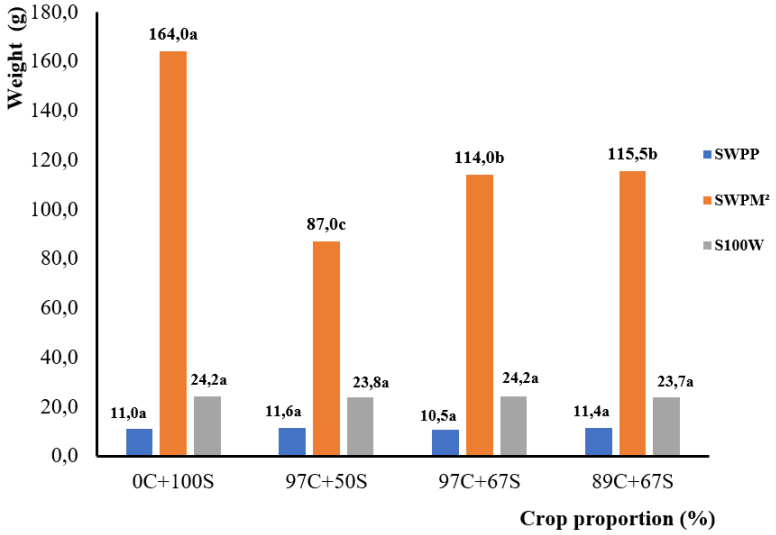

Fig. 2. Seed weight per plant (SWPP), seed weight per m² (SWPM²), and seeds 100 weight (S100W) that harvested from different crop proportion of cassava(C)-soyabean(S) double cropping. According to the DMRT test at 5% level, the crop proportion treatment did not cause differences in the average of harvest seed, except in SWPM².

The decrease in soyabean seed productivity per m2 in double cropping compared to sole cropping appears not to be caused by the emergence of competition but rather due to a reduction in the soyabean population in double cropping. It was shown by all variables of harvest seed observed (Fig. 1), namely there were no difference in yield component between that harvested from double cropping and from sole cropping. When competition in the double cropping happened, it was obviously figured in decrease of yield of soyabean occurred on soyabean-corn double cropping 1:1 caused of the suppression on the growth and yield of soyabean more than soyabean-corn crop proportion of 2:1 [9]. The yield of soyabean decreased up to 35% in soyabean-corn double cropping with a crop proportion of 120-70, which is higher than those of 70-56, namely 14.6% [10]. The yield of dry black soyabean seeds for hectares harvested from soyabean-corn double cropping with crop proportions of 4:1 to 6:1 continued increase from 1.04 to 1.65 tons [11].

If there is no yield reduction per plant, it can be suggested that there is no competition effect, then productivity of the double cropping is linear to the population. This experiment results proved the phenomenon. This result showed that the soyabean harvest seed increased linearly concomitant with the increase of the crop proportion of cassava-soyabean double cropping, namely harvest seed of 87.0 g/m², 114.0 g/m², 115.5 g/m², and 164.0 g/m² (Fig. 2). The soyabean-corn double cropping [11] was also consistence with this result.

3.3 Viability of Soyabean Seed

The viability of soyabean seeds harvested from double cropping with different crop proportions did not differ. Fig. 3 shows that four variables were measured support the statement, namely percent of normal sprouts, germination speed, percentage of strong normal sprouts, and dry weight of normal sprouts. The fourth crop proportions of double cropping yielded more than 93% of normal sprouts (PNS) for soyabean seeds. It exceeds the minimal germination capacity threshold of 80% of qualified soyabean seeds [12]. It showed that the viability of soyabean seeds harvested from cassava-soyabean double cropping and soyabean sole cropping appeared to be not differ. Once again, it is evident that there was no competition within the crop proportions of cassava-soyabean double cropping. Based on this result, the production of soyabean seeds can be ensured by double cropping soyabean and cassava. This result of the experiment showed that both of yield per plant and the viability of soyabean seed harvested from the cassava-soyabean double cropping did not reduce compared to those harvested from sole cropping. Crops will maintain the quality of the seeds produced even though they have to reduce the quantity if they experience environmental stress during their growth and development [13]. In the case of soyabean, the decrease in seed viability was more influenced by delays in postharvest handling [14] than by environmental stress.

Seeds that may be marketed are those with high viability which are indicated by germination capacity of at least 80%, or even 90-94% [15]. Seeds that have high viability are excellent, as their viability determines their storability. Seed store ability viability is determined by genetic factors, as reported for Kawali and P/F-10-90A sorghum seeds which had similar viability but at 12 months post-storage the germination capacity of Kawali was only 36.67%, much lower than P/F-10 -90A which is still 80% [16]

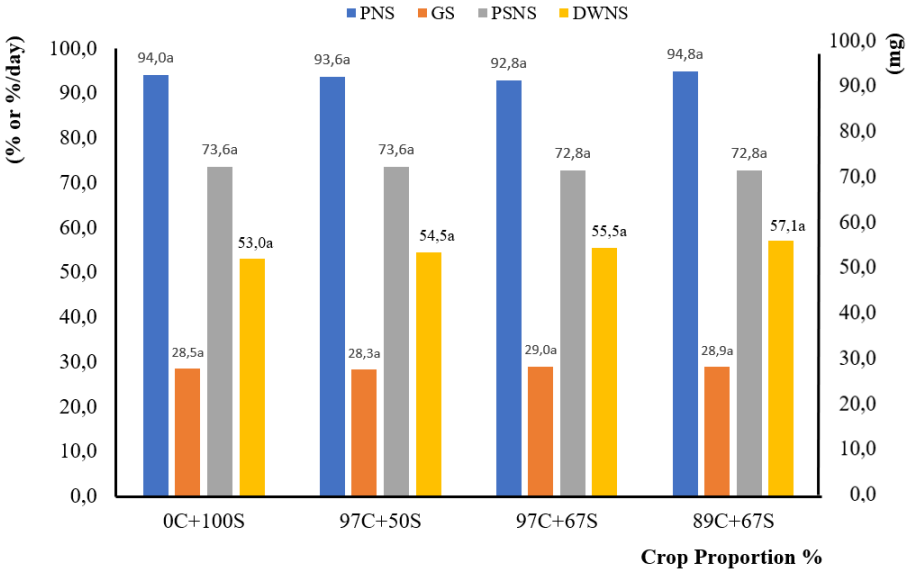

Fig. 3. Percent of normal sprouts (PNS), germination speed (GS), percent of strong normal sprouts (PSNS), and dry weight of normal sprouts (DWNS) of soyabean seed that harvested from different crop proportion of cassava(C)-soyabean(S) double cropping. According to the DMRT test at 5% level, the crop proportion treatment did not cause differences in the average seed viability.

3.4 Efficiency of land use

The cassava-soyabean double cropping with all crop proportion created the efficiency of land use (ELU) higher than those of the soyabean sole cropping as indicated by the index of planting areal equivalency (PAE) in Table 1. The PAE for cassava-soyabean double cropping was greater than one (Table 2), namely 1.49, 1.53, and 1.45. Compared to population of combination ratio (CPR), PAE did not differ significantly. The fact that there was no difference significantly on the harvest seed per plant among the crop proportion meant that cultivation technique applicated on the double cropping was right.

The cultivation technique applicated in the cassava-soyabean sole cropping included right type of crops selected, fertilizer given to each crop type, west-east row direction chosen, crop proportion of one or both crop type reduced [5]. Application of that cultivation technology can reduce or eliminate competition in sole cropping. Compared to soyabean sole cropping, this double cropping between cassava-soyabean increased efficiency of land use by 45-53%. Type of crop planted in the double cropping affects index value of PAE, such as double cropping of leeks and corn, which was 1.55 [17], even type of crop cultivar will determine PAE index [18].

Table 2. The Effect of crop proportion (PC) on planting areal equivalency (PAE) and crop proportion ratio (CPR) of the cassava-soyabean (CS) double cropping (DC) compared to sole cropping (S)

PC (in %)	Cropping system	Yield (kg/m2)		PAE M		PAE DC	CPR DC	P-value of [a]	
		Soyabean	Cassava	Soyabean	Cassava			PAE *vs* 1	PAE *vs* CPR
100C+0S	S	0.00	4.42	0.00	1.00	1.0	1.00		
0C+100S	S	0.16	0.00	1.00	0.00	1.0	1.00		
97C+50S	DC	0.09	4.18	0.53	0.96	1.49	1.47	0.02	0.89
97C+67S	DC	0.11	3.66	0.69	0.84	1.53	1.64	0.00	0.28
89C+67S	DC	0.12	3.26	0.70	0.74	1.45	1.56	0.00	0.08

[a] Note: P=probability; PAE=CPR caused of P>0.01, PAE>1 caused of P< 0.05.

4 Conclusions

Harvest seed per plant and its viability of soyabean seeds harvested from double cropping with cassava, in various different crop proportions, were not reduced from seeds harvested from sole cropping. The advantage of producing soyabean seeds by double cropping with cassava was the increase in efficiency of land use index.

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