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Evaluation of Padjadjaran maize hybrids in intercropping system with soybeans under albasia shade

Abstract. Intercropping between maize and soybean has been known to be widely practiced by subsistence farmers. Some farmers do intercropping in production forests and there are no scientific data about it. The aims of the study were to evaluate the growth and yield of Padjadjaran maize hybrids and to estimate Land Equivalent Ratio, Competitive Ratio, and Stress Tolerance Index under intercropping of maize and soybeans under the shade of Albasia. The experiment was carried out from January to June 2021 in Tanjungsari, Sumedang Regency with an altitude of 818 m above sea level. The experiment used a Randomized Block Design (RBD) which consisted of 21 treatments of Padjadjaran maize hybrids intercropped with soybeans and with three replications. For control, soybean and maize has planted by using monocropping simultaneously. The experimental results showed that hybrids of MDR 3.1.2 x MDR 153.14.1, BR 154 x MDR 153.3.2, and DR 4 x MDR 7.2.3 gave the best growth and yield components under intercropping system with soybeans. However, the other Padjadjaran hybrids gave better Land Equivalent Ratio, Competitive Ratio, and Stress Tolerance Index.

Keywords: Intercropping · Maize · Shade · Soybean

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Introduction

Food security and sovereignty is a global and national issue as it concerns the primary human needs. As the second major food after rice, maize is a commodity that has increased in demand as the food and feed industry develops. Maize itself can be utilized as food, fuel and animal feed (Skoufogianni et al., 2019). Besides maize, another important crop is soybean. It is an affordable source of vegetable protein compared to animal protein (Messina et al., 2018). Increasing population, public awareness of healthy food, and increasing per capita income are the reasons why soybean consumption will continue to increase (Ningrum et al., 2018).

A strategic alternative solution in overcoming the problems of food crop productivity and the environment is the application of intercropping systems. Intercropping is modifying the environment based on selective plant selection. Soybean is positioned as a second crop in intercropping with maize as the main crop has several requirements such as ecological (Suleimenova et al., 2019), physiological and economic aspects (Frederick & Hesketh, 2021). Maize as a C4 crop has a lower photo respiration rate than soybean as a C3 crop. The level of light saturation of maize plants is higher than soybeans, so that the photosynthetic efficiency is higher. This difference is complementary when intercropped (Yao et al., 2017). Considering the physiological aspects, the interaction between corn and soybean will be positive (Yang et al., 2017). Methods for evaluating intercropping systems generally use Land Equivalent Ratio (LER), Competitive Ratio (CR), and Stress Tolerance Index (STI) (Islam et al., 2024; Shi et al., 2022).

The maize development team of the Plant Breeding Laboratory, Padjadjaran University, has maize genotypes with specific advantages. Some of the Padjadjaran hybrid maize varieties has high yield, downy mildew resistance, warehouse pests, drought tolerance, and is rich in protein. Intercropping Padjadjaran maize hybrids and soybean under Albasia can utilize the area in alley cultivation or agroforestry. To determine the extent to which Padjadjaran maize hybrids intercropped with soybean have a level of tolerance when grown in reduced light conditions (under albasia shade), it is necessary to carry out research by measuring the extent of agronomic diversity in the Tanjungsari experimental field under albasia shade conditions. The objective of this study was to evaluate the growth and yield of Padjadjaran corn hybrids and estimate the intercropping components of LER, CR, and STI on Padjadjaran corn hybrids in maize + soybean intercropping under albasia shade.

Materials and Methods

This research was conducted on experimental land under 5 years old albasia on Tanjungsari experimental land, Kutamandiri Village, Tanjungsari District, Sumedang Regency with an elevation of 818 m above sea level from December 2020 to May 2021.

The materials used in this study included 21 maize hybrids, soybean seeds cv. Argomulyo, NPK fertilizer (15:15:15), urea fertilizer, and carbofuran insecticide. Tools used ruler (measuring height, width, and length of leaves), analytical scales (for measuring the weight of maize and soybean yield components) and luxmeter (measuring the intensity of sunlight).

The experimental design used a Randomized Block Design with twenty-one treatments of Padjadjaran maize hybrids intercropped with soybean and repeated three times. To obtain data on intercropping variables, both monocropping of soybean and maize. The number of samples per plot used in the observation was 3 samples. Data from the observations were analyzed using STAR version 2.1 with the F test at the 5% significant level to determine the difference of the treatment. If the results of the F test at the 5% level there is a significant difference, therefore, the test is continued with Duncan's multiple range test at the 5% level to determine the difference between treatment.

To facilitate the interpretation of experimental data, the data were processed and simplified by means of hybrid genotypes that had significantly different variables with good characters of more than four (>4) then the hybrid genotype was categorized as good. The good category is obtained from the mean value.

Observations made included supporting observations and main observations. Supporting observations were made on several variables, namely, weather conditions in the experimental environment (temperature, rainfall, and light intensity) and soybean yield (not statistically analyzed). The main observations included growth and yield components, and yield of maize. Growth components consist of plant height and Leaf Area Index (LAI). Yield and yield components included: Weight of cob with husk (g), Weight of cob without husk (g), Length of cob (cm), Diameter of cob (cm), Number of seed rows per cob, Number of seeds per row, Weight of kernel per cob (g), and Weight of 1000 seeds per cob (g).

Results and Discussions

General Condition of Experimental Land. This research was conducted on farmer land in Kutamandiri Village, Tanjungsari Subdistrict, Sumedang Regendy, West Java Province. The experimental plot size was 648.8 m2 and was at an altitude of 818 m above sea level. Research field was a land under the shade of 3-5 years old albasia (*Albizia chinensis*), and had Oldeman climate type C3.

Fig. 1 Research field

Rainfall, Temperature and Light Intensity in the Field. The highest rainfall occurred in March at 490 mm, while the lowest rainfall occurred in April at 44.5 mm (Table 1). Maize plants need water around 100-140 mm/month, while soybean plants grow well with rainfall of 85-100 mm per month, so it was sufficient of water (Oumarou et al., 2019; Memon & Jamsa, 2018). The highest temperature based on Table 2 was 28.8°C, while the lowest temperature was 12.5°C. The average temperature required for corn to grow optimally is 24°C during the growth period (Sánchez et al., 2014).

Table 2. Field Temperature (°C) in January-June 2021

Months	January	February	March	April	May	June
Minimum	13.7	13.4	14.1	13	12.5	13.3
Maximum	26.8	27.4	28	28.4	28.8	28.2
Average	22.5	22.8	22	22.5	23	22.6

Sources: Universitas Padjadjaran Weather Station

Corn as a C4 crop requires high light radiation and has a saturation point of 8000 - 10000 ft cd (Gunasekaran et al., 2022), while soybean as a C3 crop needs 2500 ft cd (Feng et al., 2019). The research results only reached an average of 1621.6 ft cd in intercropping Padjadjaran corn hybrids with soybeans (Table 3).

Table 3. Light Intensity

No	Hybrids	Intensity of light (ft cd)
1	DR 11 x DR 16	1691.4
2	DR 4 x MDR 16.6.14	1211.3
3	DR 6 x DR 7	1406.4
4	MDR 9.1.3 x MDR 1.1.3	1236.1
5	MDR 3.1.4 x MDR 18.5.1	1369.3
6	BR 154 x MDR 18.8.1	1487
7	MDR 3.1.2 x MDR 153.14.1	1490.1
8	DR 10 x MDR 9.1.3	1372.4
9	DR 4 x MDR 7.2.3	1090.5
10	MDR 18.8.1 x MDR 7.1.9	1384.8
11	MDR 7.4.3 x DR 18	1391
12	MDR 7.4.3 x MDR 1.1.3	1679.1
13	DR 8 x MDR 18.8.1	1267
14	DR 5 x MDR 18.8.1	1586.1
15	DR 8 x MDR 1.1.3	1087.4
16	DR 19 x DR 20	1341.4
17	MDR 7.4.3 x MDR 18.8.1	1620.2
18	DR 8 x DR 9	1025.4
19	DR 7 x DR 8	1902.1
20	BR 154 x MDR 153.3.2	1260.8
21	DR 14 x DR 18	1325.9
22	Sole cropping of soybean	6449.8

Table 1. Rainfall (mm) in January-June 2021.

Months	January	February	March	April	May	June	Average
Rainfall (mm)	377	118	490	44.5	120.5	85.5	205.9

Sources: Universitas Padjadjaran Weather Station

Soybean yield. Soybean yield data were not statistically analyzed (Table 4). The data were used to calculate Land Equivalent Ratio (LER), Competitive Ratio (CR), and Stress Tolerance Index (STI). Based on Table 4, the yield of single crop soybean is 780 g per plot (2.5 t per ha), while the yield of intercropped soybean ranges from 290 - 461.2 g per plot (0.9 - 1.5 t per ha). Based on the description of Argomulyo, the productivity of Argomulyo soybean varieties planted singly is 1.5 - 2 t per ha.

Table 4. Yield of soybean under intercropping with maize.

No	Intercrop with maize hybrids	Seed weight of soybean per plot (g)	Seed weight of soybean per ha (ton)
1	DR 4 x MDR 7.2.3	361	1.2
2	DR 4 x MDR 16.6.14	384	1.2
3	DR 5 x MDR 18.8.1	397.2	1.3
4	DR 6 x DR 7	290	0.9
5	DR 7 x DR 8	377	1.2
6	DR 8 x MDR 18.8.1	361	1.2
7	DR 8 x DR 9	381	1.2
8	DR 8 x MDR 1.1.3	441.6	1.4
9	DR 10 x MDR 9.1.3	400	1.3
10	DR 11 x DR 16	361	1.2
11	DR 14 x DR 18	391.2	1.2
12	DR 19 x DR 20	461.2	1.5
13	MDR 3.1.4 x MDR 18.5.1	391	1.2
14	MDR 3.1.2 x MDR 153.14.1	401	1.3
15	MDR 7.4.3 x DR 18	369	1.2
16	MDR 7.4.3 x MDR 18.8.1	461	1.5
17	MDR 7.4.3 x MDR 1.1.3	394.8	1.3
18	MDR 9.1.3 x MDR 1.1.3	376	1.2
19	MDR 18.8.1 x MDR 7.1.9	377	1.2
20	BR 154 x MDR 18.8.1	421	1.3
21	BR 154 x MDR 153.3.2	349	1.1
22	Soybean sole cropping	780	2.5

Growth components. Based on Table 5, 21 genotypes of Padjadjaran maize hybrids have a non-diverse appearance in both plant height and LAI. Plant height ranged from 90.78 - 142.44 cm. DR 5 x MDR 18.8.1 (No 3) is the maize hybrid with the highest plant height while MDR 3.1.4 x MDR 18.5.1 (No 13) is the shortest hybrid. DR 4 x MDR 7. 2.3 (No 1) and MDR 9.1.3 x MDR 1.1.3 (No 18) were the hybrids that had the largest leaf area index (LAI), and MDR 3.1.4 x MDR 18.5.1 (No 13) had the lowest LAI. This indicates that the obtained light intensity range of 1,621 ft cd (Table 5) did not have a negative effect on plant height and LAI of Padjadjaran maize hybrids.

LAI is a variable that shows the potential of plants to carry out photosynthesis which directly affects plant growth and development. Leaf area is a measure of the potential ability of plants in the plant. The larger the leaf area, the more sunlight that can be absorbed so that the photosynthesis process will increase (Perez et al., 2019).

Table 5. Plant height and Leaf Area Index (LAI) of maize at 12 Weeks After Sowing (WAS).

No	Hybrids	Plant Height (cm)	LAI
1	DR 4 x MDR 7.2.3	137.89 a	4.98 a
2	DR 4 x MDR 16.6.14	134.22 a	4.88 a
3	DR 5 x MDR 18.8.1	142.44 a	4.25 a
4	DR 6 x DR 7	128.44 a	4.90 a
5	DR 7 x DR 8	119.78 a	4.20 a
6	DR 8 x MDR 18.8.1	118.00 a	4.93 a
7	DR 8 x DR 9	116.78 a	4.26 a
8	DR 8 x MDR 1.1.3	116.56 a	3.44 a
9	DR 10 x MDR 9.1.3	136.22 a	4.32 a
10	DR 11 x DR 16	124.22 a	4.63 a
11	DR 14 x DR 18	127.78 a	4.40 a
12	DR 19 x DR 20	124.56 a	4.17 a
13	MDR 3.1.4 x MDR 18.5.1	90.78 a	3.10 a
14	MDR 3.1.2 x MDR 153.14.1	113.33 a	4.94 a
15	MDR 7.4.3 x DR 18	112.78 a	3.76 a
16	MDR 7.4.3 x MDR 18.8.1	121.11 a	4.17 a
17	MDR 7.4.3 x MDR 1.1.3	106.11 a	4.43 a
18	MDR 9.1.3 x MDR 1.1.3	131.11 a	4.98 a
19	MDR 18.8.1 x MDR 7.1.9	121.11 a	4.35 a
20	BR 154 x MDR 18.8.1	120.17 a	4.63 a
21	BR 154 x MDR 153.3.2	105.00 a	4.33 a

Notes: mean values followed by the same letter in the same column are not significantly different according to the DMRT test at the 5% level.

Yield Components and Yield

Weight of Cob with Husk per Plant and Weight of Cob without Husk per Plant. The weight of cob with husk per plant was shown in Table 6. It can be seen that generally the weight of cob with husk per plant is very diverse. Each genotype has different values with the best result of 172.22 g. in DR 4 x MDR 7.2.3 (No 1) and the lowest is 67.04 g. in DR 8 x MDR 18.8.1 (No 6). Based on the weight of cob without husk per plant shown in Table 6, it revealed that the weight of unhusked cob per plant is very diverse. Each genotype has different values with the best result of 120 g. on DR 4 x MDR 7.2.3 (No 1) and the lowest is 52.44 g. on DR 4 x MDR 16.6.14 (No 2).

The difference in cob weight can be caused by several things, such as genetic factors and the ability to compete for each genotype in terms of growth space and nutrients with companion plants (Maqbool, 2016). Intercropping systems are characterized by interactions in the underground and aboveground. This is because each plant has its own needs to survive, so the main plant and companion plants compete in meeting the needs of water, nutrients and sunlight (Ren et al., 2021).

Cob length and diameter. In Table 6, maize cob length showed no significant difference from all treatments. In this experiment, cob length ranged from 10.56 - 14.89 cm. The longest cob length was found in DR 11 X DR 16 (No 10) and the smallest in BR 154 X MDR 18.8.1 (No 20). Based on Table 7, cob diameter in this experiment showed no significant difference in all treatments. The cob diameter ranged from 2.25 - 3.11 cm. The largest cob diameter was in MDR 18.8.1 X MDR 7.1.9 (No. 19) and the smallest was in DR 8 X MDR 1.1.3 (No 8).

The length and diameter of the cob that were not significantly different from all treatments were thought to be because the plants received sufficient sunlight intensity for the growth of cob length and diameter of 1.621 ft cd (Table 5). This shows that light intensity does not have a negative effect on cob length and diameter variables. Intercropping maize hybrids and soybeans did not have a negative effect on cob length and diameter.

Table 6. Yield components and yield as indicated by variable of weight of cob with husk per plant, weight of cob without husk per plant, length of cob, and cob diameter in maize cultivated under intercropping with soybean.

No	Hybrids	WCH (g)	WCWH (g)	LC (cm)	CD (cm)
1	DR 4 x MDR 7.2.3	172.22 a	120 a	13.00 a	2.50 a
2	DR 4 x MDR 16.6.14	77.78 hi	52.44 h	13.44 a	3.00 a
3	DR 5 x MDR 18.8.1	122.50 bcdefg	82.50 defg	16.00 a	3.00 a
4	DR 6 x DR 7	107.78 cdefgh	78.89 defgh	14.33 a	3.06 a
5	DR 7 x DR 8	89.63 fghi	68.15 fgh	11.44 a	2.89 a
6	DR 8 x MDR 18.8.1	67.04 i	89.55 bcdef	13.50 a	2.88 a
7	DR 8 x DR 9	106.67 cdefgh	78.34 defgh	12.33 a	2.61 a
8	DR 8 x MDR 1.1.3	113.33 bcdefgh	114.44 abc	10.83 a	2.25 a
9	DR 10 x MDR 9.1.3	121.48 bcdefg	85.93 cdefg	13.94 a	2.94 a
10	DR 11 x DR 16	105.56 cdefghi	75.55 defgh	14.89 a	3.28 a
11	DR 14 x DR 18	138.15 abcd	104.44 abcd	12.89 a	2.83 a
12	DR 19 x DR 20	130 bcdef	103.70 abcd	14.00 a	2.72 a
13	MDR 3.1.4 x MDR 18.5.1	120 bcdefg	84.45 defg	11.11 a	2.78 a
14	MDR 3.1.2 x MDR 153.14.1	145.55 abc	100.74 abcde	14.28 a	3.06 a
15	MDR 7.4.3 x DR 18	87.78 ghi	57.04 gh	12.78 a	2.28 a
16	MDR 7.4.3 x MDR 18.8.1	94.08 efghi	75.55 defgh	13.67 a	2.50 a
17	MDR 7.4.3 x MDR 1.1.3	91.11 fghi	63.89 fgh	14.33 a	2.39 a
18	MDR 9.1.3 x MDR 1.1.3	150.37 ab	115.56 ab	14.22 a	3.06 a
19	MDR 18.8.1 x MDR 7.1.9	132.22 bcde	104.44 abcd	13.67 a	3.11 a
20	BR 154 x MDR 18.8.1	110 cdefgh	83.70 defg	10.56 a	2.81 a
21	BR 154 x MDR 153.3.2	104.45 defghi	73.78 efgh	12.22 a	2.83 a

Notes: WCH = Weight of Cob with husk per plant, WCWH = Weight of Cob without husk per plant, LC = Length of Cob, CD = Cob Diameter

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Table 7. Yield components and yield as indicated by variable of number of cob rows, number of seeds per row per cob, seed weight per cob, weight of 1000 seeds in maize cultivated under intercropping with soybean.

No	Hybrids	NR	NSR	SW (g)	1000W (g)
1	DR 4 x MDR 7.2.3	12.44 a	23.22 a	414.67 abcd	1056.67 abcde
2	DR 4 x MDR 16.6.14	12.44 a	24.11 a	417.67 abcd	781.67 cdef
3	DR 5 x MDR 18.8.1	12.44 a	28.22 a	392.33 abcd	1206.67 abcd
4	DR 6 x DR 7	12.11 a	28.56 a	384.67 bcd	1380.00 ab
5	DR 7 x DR 8	12.33 a	20.33 a	391.67 abcd	816.67 bcdef
6	DR 8 x MDR 18.8.1	11.75 a	27.75 a	361.67 cd	607.50 ef
7	DR 8 x DR 9	11.67 a	19.67 a	444.33 ab	820.00 bcdef
8	DR 8 x MDR 1.1.3	11.78 a	22.25 a	385.33 bcd	907.50 abcdef
9	DR 10 x MDR 9.1.3	11.89 a	21.89 a	406.33 abcd	1096.67 abcde
10	DR 11 x DR 16	12.44 a	27.56 a	443.00 ab	1133.33 abcde
11	DR 14 x DR 18	12.89 a	19.22 a	361.67 cd	1133.87 abcde
12	DR 19 x DR 20	12.33 a	20.11 a	462.67 a	649.33 def
13	MDR 3.1.4 x MDR 18.5.1	12.00 a	20.22 a	345.00 bcd	920.00 abcdef
14	MDR 3.1.2 x MDR 153.14.1	12.44 a	28.78 a	355.00 d	1463.33 a
15	MDR 7.4.3 x DR 18	10.89 a	22.11 a	409.67 abcd	830.00 bcdef
16	MDR 7.4.3 x MDR 18.8.1	12.78 a	23.78 a	421.33 abcd	400.02 f
17	MDR 7.4.3 x MDR 1.1.3	12.00 a	20.00 a	424.00 abcd	890.03 bcdef
18	MDR 9.1.3 x MDR 1.1.3	12.00 a	28.00 a	440.33 ab	1233.33 abc
19	MDR 18.8.1 x MDR 7.1.9	14.22 a	21.56 a	427.33 abcd	1179.97 abcde
20	BR 154 x MDR 18.8.1	11.78 a	17.78 a	433.33 abc	834.67 bcdef
21	BR 154 x MDR 153.3.2	13.11 a	26.00 a	396.67 abcd	645.00 def

Notes: NR = Number of cob rows, NSR = Number of Seeds per Row per Cob, SW = Seed Weight per cob, 1000W = Weight of 1000 seeds.

Number of rows per cob and number of seeds per cob. Based on Table 7, the number of rows per cob of corn plants showed no significant difference from all treatments. In this experiment, the number of rows per cob ranged from 10.89 - 14.22 rows. The highest number of rows per cob was found in MDR 18.8.1 x MDR 7.1.9 (No 19) and the smallest in MDR 7.4.3 x DR 18 (No 15). The number of seeds per row per cob in this experiment showed no significant difference in all treatments. The number of seeds per row per cob ranged from 17.78 - 28.78 seeds per row per cob. The highest number of seeds per row per cob was found in MDR 3.1.2 x MDR 153.14.1 (No 14) and the smallest in BR 154 x MDR 18.8.1 (No 20).

The number of rows per cob and the number of seeds per cob that were not significantly different from all treatments were thought to be because the plants received sufficient sunlight intensity for the number of rows per cob and the number of seeds per cob of 1,621 ft cd (Table 3). This shows that light intensity does not have a negative effect on the variables of cob length and diameter. Intercropping maize and soybean did not have a negative effect on the number of rows per cob and the number of seeds per cob.

Seed Weight per Cob and 1000 Seeds Weight. Based on seed weight per cob shown in Table 7, it can be seen that generally the weight of seeds per cob is very diverse. In this experiment, each genotype has different values with the best result of 1463.33 g. on MDR 3.1.2 x MDR 153.14.1 (No. 14) and the worst is 400.02 g. on MDR 7.4.3 x MDR 18.8.1 (No. 16). The results of experiments on 1000 seed weight shown in Table 7, it can be seen that the 1000 seeds weight is generally 391.67 - 427.33 g. The genotype with the highest 1000 seed weight was DR 19 x DR 20 (No 12) and the lowest was MDR 3.1.2 x MDR 153.14.1 (No 14).

Seed weight per sample and 1000 seeds weight that have a significant effect on each treatment can be expected because each genotype of maize plants has different genetic factors. Genetic factors that cause differences in yield are that each genotype has the ability to absorb different nutrients and each genotype has its own yield characteristics that are the advantages of the genotype. The intercropping maize hybrids with soybeans under the shade of

5 years old albasia has diverse results in 1000 seeds weight and seed weight per cob due to differences in the intensity of light received in each research plot.

The intercropping maize hybrids with soybean and planting under the shade of 5 years old albasia are the reasons for the weight of seeds per cob and the weight of 1000 seeds to have diverse results. To facilitate the interpretation of data from Tables 6 and 7, the data were processed and simplified as shown in Table 8, especially for variables that showed significant differences. Based on Table 8, hybrids that have significantly different variables with good characters of more than four (>4) are DR 4 x MDR 7.2.3 (No. 1), DR 14 x DR 18 (No. 11), and MDR 9.1.3 x MDR 1.1.3 (No 18).

Table 8. Padjadjaran maize hybrids that have a significantly different number of variables with good characters.

No	Hybrids	Variable(s) with Good Character
1	DR 4 x MDR 7.2.3	5
2	DR 4 x MDR 16.6.14	1
3	DR 5 x MDR 18.8.1	2
4	DR 6 x DR 7	1
5	DR 7 x DR 8	1
6	DR 8 x MDR 18.8.1	2
7	DR 8 x DR 9	1
8	DR 8 x MDR 1.1.3	4
9	DR 10 x MDR 9.1.3	2
10	DR 11 x DR 16	1
11	DR 14 x DR 18	5
12	DR 19 x DR 20	3
13	MDR 3.1.4 x MDR 18.5.1	1
14	MDR 3.1.2 x MDR 153.14.1	3
15	MDR 7.4.3 x DR 18	1
16	MDR 7.4.3 x MDR 18.8.1	1
17	MDR 7.4.3 x MDR 1.1.3	1
18	MDR 9.1.3 x MDR 1.1.3	6
19	MDR 18.8.1 x MDR 7.1.9	4
20	BR 154 x MDR 18.8.1	1
21	BR 154 x MDR 153.3.2	1

Notes: Data are obtained from Tables 6 and 7.

Evaluation of Padjadjaran Maize Hybrids in Intercropping with Soybean under Albasia Shade Based on Intercropping Variables. In Table 9 when related to light intensity caused by albasia shading, it can be seen that almost 50% of sole cropping maize has lower yield than intercropping. The low light intensity of 1,621 ft cd (Table 3) was the main factor in the low yield of maize in both sole and intercropping. The higher yield of intercropped maize than sole cropping maize was probably due to the fact that the intercropped maize received N nutrients from soybean. In some genotypes that have lower yields are caused by genetic factors. In soybeans, it is clear that the results of intercropped soybeans have lower yields than sole cropping soybean, there is a decrease of almost 50%. Soybeans in this case experience greater shade disturbance because they are under the shade of albasia and maize. Based on Table 9, the results of intercropping maize hybrid with soybean under the shade of 5 years old albasia had an average yield of 3.02 tons per ha (951.72 g per plot) for Padjadjaran maize hybrid and 1.24 tons per ha (885.15 g per plot). The sole cropping obtained in other experiments in the same planting time had yields of 3.19 tons per ha (1003.51 g. per plot) for Padjadjaran maize hybrid and 2.5 tons per ha (780 g per plot).

Based on Table 10, the highest LER is DR 14 x DR 18 (No 11) and MDR 3.1.4 x MDR 18.5.1 (No 13) at 2.49. This value indicates that intercropping corn and soybean is more profitable than sole cropping. The lowest LER was DR 8 x MDR 18.8.1 (No. 6) at 0.93 indicating that this treatment gave a loss compared to sole cropping because it was less than 1. LER more than 1 indicates the agronomic advantage of intercropping (Li et al., 2020).

Competitive ratio of maize (CRm) was highest in DR 6 x DR 7 (No 4) at 4.15. This is the reason DR 6 x DR 7 (No 4) has a high CRm because of its ability to compete with soybean and produce higher seed weight per plot than single cropping. DR 6 x DR 7 (No 4) has a yield of 4.4 tons per ha and 0.9 tons per ha for soybean yield and has a CRs value of 0.24.

Based on Table 10, CRm values are generally higher than CRs, due to the characteristics and architecture of maize plants that are more favorable in resource uptake. The more aggressive root system of maize allows it to spread close to soybean rows, absorbing nutrients from soybean (Lv et al., 2014). This is because soybean is a microbial-associated plant capable of fixating N and contributing to soil fertility.

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Table 9. Yield of maize and soybean under sole and intercropping.

No	Maize hybrids	Yield			
		Sole cropping (ton)		Intercropping (ton)	
		Maize	Soybean	Maize	Soybean
1	DR 4 x MDR 7.2.3	2.8	2.5	3.4	1.2
2	DR 4 x MDR 16.6.14	4.4	2.5	2.5	1.2
3	DR 5 x MDR 18.8.1	3.1	2.5	3.8	1.3
4	DR 6 x DR 7	2.8	2.5	4.4	0.9
5	DR 7 x DR 8	2.6	2.5	2.6	1.2
6	DR 8 x MDR 18.8.1	4.1	2.5	1.9	1.2
7	DR 8 x DR 9	3.3	2.5	2.6	1.2
8	DR 8 x MDR 1.1.3	2.7	2.5	2.9	1.4
9	DR 10 x MDR 9.1.3	2.3	2.5	3.5	1.3
10	DR 11 x DR 16	6.7	2.5	3.6	1.2
11	DR 14 x DR 18	1.8	2.5	3.6	1.2
12	DR 19 x DR 20	2.2	2.5	2.1	1.5
13	MDR 3.1.4 x MDR 18.5.1	1.5	2.5	2.9	1.2
14	MDR 3.1.2 x MDR 153.14.1	4.2	2.5	4.7	1.3
15	MDR 7.4.3 x DR 18	3.8	2.5	2.6	1.2
16	MDR 7.4.3 x MDR 18.8.1	3	2.5	1.3	1.5
17	MDR 7.4.3 x MDR 1.1.3	3.4	2.5	2.8	1.3
18	MDR 9.1.3 x MDR 1.1.3	3.5	2.5	3.9	1.2
19	MDR 18.8.1 x MDR 7.1.9	4.5	2.5	3.7	1.2
20	BR 154 x MDR 18.8.1	2.2	2.5	2.6	1.3
21	BR 154 x MDR 153.3.2	2	2.5	2	1.1

Table 10. Parameter of cropping system maize + soybean.

No	Hybrids	LER	CRm	CRs	STI
1	DR 4 x MDR 7.2.3	1.65	2.56	0.39	0.46
2	DR 4 x MDR 16.6.14	1.05	1.13	0.88	0.49
3	DR 5 x MDR 18.8.1	1.76	2.46	0.41	0.51
4	DR 6 x DR 7	1.91	4.15	0.24	0.37
5	DR 7 x DR 8	1.5	2.1	0.48	0.48
6	DR 8 x MDR 18.8.1	0.93	1.01	0.99	0.46
7	DR 8 x DR 9	1.29	1.64	0.61	0.49
8	DR 8 x MDR 1.1.3	1.64	1.9	0.53	0.57
9	DR 10 x MDR 9.1.3	2	2.9	0.34	0.51
10	DR 11 x DR 16	1	1.17	0.86	0.46
11	DR 14 x DR 18	2.49	3.97	0.25	0.5
12	DR 19 x DR 20	1.52	1.56	0.64	0.59
13	MDR 3.1.4 x MDR 18.5.1	2.49	3.96	0.25	0.5
14	MDR 3.1.2 x MDR 153.14.1	1.63	2.17	0.46	0.51
15	MDR 7.4.3 x DR 18	1.17	1.48	0.68	0.47
16	MDR 7.4.3 x MDR 18.8.1	1.01	0.71	1.41	0.59
17	MDR 7.4.3 x MDR 1.1.3	1.33	1.64	0.61	0.51
18	MDR 9.1.3 x MDR 1.1.3	1.6	2.32	0.43	0.48
19	MDR 18.8.1 x MDR 7.1.9	1.31	1.71	0.58	0.48
20	BR 154 x MDR 18.8.1	1.74	2.23	0.45	0.54
21	BR 154 x MDR 153.3.2	1.49	2.33	0.43	0.45

Notes: LER = Land Equivalent Ratio, CRm = Maize Competitive Ratio, CRs = Soybean Competitive Ratio, STI = Stress Tolerance Index

The lowest CRm in the tested hybrids was owned by MDR 7.4.3 x MDR 18.8.1 (No 16) at 0.71 which indicates a low level of competition to soybean and has the highest CRs at 1.41. MDR 7.4.3 x MDR 18.8.1 (No 16) had a yield of 1.3 tons per ha and 1.5 tons per ha for soybean yield. This is due to interspecific competition between maize and soybean so that the maize genotypes that have weak competition have decreased yield compared to single maize.

The STI of Padjadjaran maize hybrids and soybean ranged from 0.37 to 0.59, implying that the tested maize hybrids provided low enough stress to soybean that maize showed to be more competitive than soybean in intercropping system. Based on the results, the selected maize hybrids should also have high yielding power both in single planting and intercropping. Based on these criteria, the selected maize hybrids are DR 4 x MDR 7.2.3 (No. 1), DR 4 x MDR 16.6.14 (No. 2), DR 5 x MDR 18.8.1 (No. 3), DR 6 x DR 7 (No. 4), DR 7 x DR 8 (No. 5), DR 8 x DR 9 (No. 7), DR 8 x MDR 1.1.3 (No. 8), DR 10 x MDR 9.1.3 (No. 9), DR 14 x DR 18 (No 11), DR 19 x DR 20 (No 12), MDR 1.4 x MDR 18.5.1 (No 13), MDR 3.1.2 x MDR 153.14.1 (No 14), MDR 7.4.3 x DR 18 (No 15), MDR 7.4. 3 x MDR 1.1.3 (No 17), MDR 9.1.3 x MDR 1.1.3 (No 18), MDR 18.8.1 x MDR 7.1.9 (No 19), BR 154 x MDR 18.8.1 (No 20), and BR 154 x MDR 153.3.2 (No 21).

Conclusions

Based on the research results, the conclusions that can be drawn are:

1. Agronomic performance of Padjadjaran hybrid maize intercropped with soybean in Tanjungsari, Sumedang Regency has diverse results.
2. Padjadjaran maize hybrids intercropped with soybean that have the best results and more than four (>4) good characters both from the growth phase, yield components, and yield are hybrids DR 4 x MDR 7.2.3 (No 1), DR 14 x DR 18 (No 11), and MDR 9.1.3 x MDR 1.1.3 (No 18).
3. Based on intercropping variables, the genotypes that have the best value in corn + soybean intercropping are DR 4 x MDR 7.2.3 (No 1), DR 4 x MDR 16.6.14 (No 2), DR 5 x MDR 18.8.1 (No 3), DR 6 x DR 7 (No 4), DR 7 x DR 8 (No 5), DR 8 x DR 9 (No 7), DR 8 x MDR 1.1.3 (No 8), DR 10 x MDR 9.1. 3 (No 9), DR 14 x DR 18 (No 11), DR 19 x DR 20 (No 12), MDR 3.1.4 x MDR 18.5.1 (No 13), MDR 3.1.2 x MDR 153.14.1 (No 14), MDR 7.4.3 x DR 18 (No 15), MDR 7. 4.3 x MDR 1.1.3 (No 17), MDR 9.1.3 x MDR 1.1.3 (No 18), MDR 18.8.1 x MDR 7.1.9 (No 19), BR 154 x MDR 18.8.1 (No 20), and BR 154 x MDR 153.3.2 (No 21).

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