Tadeusz MICHALSKI[1], Ireneusz KOWALIK[2], Piotr SZULC[1], Hubert WALIGÓRA[1], Rafał SOBIESZCZAŃSKI[1]
[1] Department of Agronomy, University of Life Sciences
[2] Institute of Biosystems Engineering, University of Life Sciences
ul. Wojska Polskiego 28, 60-623 Poznań, Poland
e-mail: tamich@up.poznan.pl

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YIELDING AND PLANT STRUCTURE OF MAIZE INTERCROPPED WITH SORGHUM

Summary

The studies were conducted in 2010-2012, at the Agricultural Experimental Station in Swadzim (52°26'20"N, 16°44'58"E), belonging to the Poznań University of Life Sciences, Poland. The response to sorghum intercropping of two maize varieties: Absolut (medium-early FAO 250) and medium-late Vitras (FAO 270) was evaluated, with reference to pure sowing as a control. Sorghum was represented by the medium-late variety GK Aron and late Sucrosorgo 506. Intercropping with the sorghum resulted in a slight decrease in maize yield, as compared to pure sowing. The larger differences were observed in mix-cropping with the sorghum cultivar Sucrosorgo 506, whose neighborhood reduced yields of fresh maize by 9,2%, dry matter yields by 6%, and the share of cobs by 3% compared to pure sowing. While intercropping with lower and less yielded cultivar GK Aron, the structure of plants and maize yields were similar to that obtained in pure sowing. Due to late harvest near 20 October, the dry matter content in maize yield varied from 30 to 42%, indicating the possibility of obtaining the recommended 30-35% d.m. in the mixed yield of maize and sorghum. The cultivars studied: Absolut and Vitras were characterized by high biomass production - yielding about 600 dt of green mass and 210-240 dt of dry matter per hectare and a share of corn cobs of 52-55%. Maize variety differences in response to the intercropping with sorghum were small and variable in years. On average, Vitras proved to be slightly better cultivar in this respect.
Key words: *maize, sorghum, intercropping, pure sowing, cultivars*

PLONOWANIE I STRUKTURA ROŚLIN KUKURYDZY UPRAWIANEJ WSPÓŁRZĘDNIEZ SORGIEM

Streszczenie

Badania przeprowadzono w latach 2010-2012 w Swadzimiu (52°26'20"N, 16°44'58"E), stacji należącej do Uniwersytetu Przyrodniczego w Poznaniu. Oceniano reakcję dwóch odmian kukurydzy (średniowczesna Absolut FAO 250 i średniopóźna Vitras FAO 270) na uprawę współrzędną z sorgiem, w odniesieniu do siewu czystego jako obiektu kontrolnego. Sorgo reprezentowane było przez odmianę średniopóźną GK Aron i późną Sucrosorgo 506. Współrzędna uprawa z sorgiem skutkowała niewielkim zmniejszeniem plonowania kukurydzy, w porównaniu do uprawy w siewie czystym. Większe różnice wystąpiły w przypadku sorga odmiany Sucrosorgo 506, której sąsiedztwo zmniejszyło plony świeżej masy kukurydzy o 9,2%, plony suchej masy o 6%, zaś udział kolb o 3%, w porównaniu do uprawy w siewie czystym. Przy uprawie współrzędnej z mniej plenną i niższą odmianą GK Aron, struktura roślin i plony kukurydzy były zbliżone do uzyskiwanych w siewie czystym. W warunkach późnego zbioru (ok. 20 października)., zawartość suchej masy w plonie kukurydzy wahała się od 30 do 42%, co wskazuje na możliwość uzyskania zalecanych 30-35% s.m. w łącznym plonie kukurydzy i sorgo. Badane odmiany: Absolut i Vitras charakteryzowały się wysoką produkcją biomasy - plonowały na poziomie około 600 dt zielonej masy i 210-240 dt suchej masy z hektara, oraz udziałem kolb, rzędu 52-55% s.m. plonu. Różnice odmianowe kukurydzy w reakcji na współrzędną uprawę z sorgo były niewielkie i zmienne w latach. W ujęciu średnim nieco lepszą pod tym względem okazała się Vitras.
Słowa kluczowe: *kukurydza, sorgo, uprawa współrzędna, siew czysty, odmiany*

1. Introduction

Maize silage in modern livestock breeding is the basis of feeding the ruminants. However, the high proportion of light soils in Poland and the ever-present summer drought make the yielding of maize silage variable and the crop does not always provide adequate supply of feed [11, 12, 13, 16, 20, 24]. Thus, alternative crops are being sought, which, in poorer soils and under conditions of water shortage, will provide the right yield. The related species is sorghum (Sorghum bicolor (L.) Moench), which under our conditions is a typical silage plant. It is a one-year species with C4 photosynthesis, high biomass production capacity and a high variability in yield and yield quality [10, 14, 17]. Sorghum has a strong root system and, thanks to its lower transpiration rate, is more resistant to drought than maize. In drought periods it is more efficient than other grasses to get water from deeper layers of soil [1, 2, 10, 15, 17]. It is considered that the theoretical potential of sorghum yield is higher than that of maize, but the experience in Europe indicates that under conditions of sufficient humidity maize has better fodder value and higher yield [2, 4, 15, 18, 21].

Green sorghum is a good silage because of the high content of simple sugars but too low the dry matter content causes considerable losses during the sowing. The sorghum contains twice as much of raw fiber and 1/3 less of nitrogen-free compounds than maize silage. The low dry matter content and low nutrient concentrations are related to the lack of early sorghum cultivars and, consequently, low seed yield [1, 14, 24]. While increasing the importance of sorghum in Europe, more and more early varieties with higher content of d.m. are available to the farmers. They have a greater share of generative parts in the plant, but they still cannot replace maize as the main feed for cows [12, 14, 16, 18, 20, 25].

In order to use sorghum and maize efficiently, an intercropping crop of maize and sorghum can be used, ie 2 + 2 rows, 4 + 2 rows or 2 + 4 rows. It allows the use of high energy maize and the high biomass potential of sorghum, manifested in poorer agrotechnical conditions. The technology is often referred as "mix cropping" [2, 3, 4]. The advantages of such technology include: (1) improvement of quality parameters (s.m. content, sugar, starch) by selecting the sowing proportion and the corresponding variety of maize; (2) higher yields and more efficient use of water and nutrients on light soils and in lean years; (3) easier ensiling - sorghum plants contain more sugar and stay longer green, and simultaneous collection of both substrates gives uniform silage; (4) better health of the field - sorghum plants are not infested by Ustillago zeae and damaged by the corn borer [2, 4, 21].

By maize intercropping with sorghum the interaction with the plants must be taken into consideration. Although both species have similar plant habit, there is usually other height of the plant, other developmental rhythm as well as the shelf-life. Interspecific competition for water, nutrients and space for development of above-ground parts in intercropping may result in lower yields of the less competitive component and a change in the proportion of the plant compared to pure cultivating. Under conditions of good humidity, maize can shade sorghum, but in the case of drought, it is expected to reduce the share of flasks and premature maturation of maize [4, 23]. Liszka-Podkowa [8] stated in the growing of bean, intercropping with maize, less number of pods produced. A similar phenomenon is observed when cultivating cereal or cereal-grain mixtures. The development of plants and, consequently, competition between species is also influenced by agrotechnical factors such as mineral fertilization, density and proportion of sowing or variety selection [4, 5, 7, 8, 10, 20, 22].

The purpose of the study was to evaluate the response of two maize cultivars to intercropping with sorghum, in a two-row system of two species. In the research hypothesis it was assumed that maize intercropping with sorghum differed in plant structure and yield from the surface unit from pure maize and that the selection of maize and sorghum varieties influenced the size of these changes.

2. Material and methods

The studies were conducted in 2010-2012, at the Agricultural Experimental Station in Swadzim (52°26′20″N, 16°44′58″E), belonging to the Poznań University of Life Sciences, Poland. The experiments were set up by split-plot method, where the first order factor included maize sowing: a - in pure sowing, b - in intercropping with medium sorghum variety: GK Aron (GabonaKutato) and c - in sowing with late variety: Sucrosorgo 506 (Syngenta Seeds). As a factor II of the order, two varieties of maize were tested: Absolut (Limagrain, FAO 250) and Vitras (HR Smolice, FFAO 270). Both cultivars of maize are characterized by a high biomass production potential and a good share of the cobs.

The experiment was carried out in four replications, in slightly acidic (pHKCL 5,5-6,0) fallow soil, class IVa to IVb, with mean phosphorus and potassium content. Maize was sown in the last days of April on ½ of the plot, leaving 2 rows unoccupied (for sorghum). The sorghum was sown approximately 3 weeks later, in the second decade of May. The size of plots for harvesting was 12,25 m2 (2 rows x 0,7 x 8,750 m). Maize and sorghum were seeded with pneumatic seed drill, with a density of 90.000 maize grains and 20.400 sorghum grains per hectare. Maize and sorghum were harvested in the third decade of October to obtain a high dry matter content in yield. In this period the maize was in late-wax maturity to full. Maize biomass yields and the share of cobs were determined over the entire area of the plot and the yield structure of the rest of the plants, ie. stem and leaf fraction was assessed on a sample of 10 plants in 1 row. During harvesting, samples for dry matter content were taken in the above parts of the plants. The maize yields were evaluated in fresh and dry matter. The synthesis of 3-year results by variance analysis was performed and LSD was calculated by Tukey's test at significance level p≤0.05. For a better assessment of weather conditions the hydrothermal coefficient was calculated according to the Selianinov method [according to 5] by the formula:

$$K = \frac{sum\ of\ rainfall \cdot 10}{average\ temperature \cdot number\ of\ days}$$

It assumes that K = 1-2 values show sufficient humidity and below 0,5 - drought. 1 is the border digit.

3. Results and discussion

The weather conditions during the years of the tests were quite favorable, both for maize and sorghum and the temperatures of the vegetation period exceeded the multiannual average. 2010 was relatively the coldest year, with cool spring and autumn and very hot summer. The average temperature of May-October 2010 was 15,4 ° C (Table 1). In the years 2011 and 2012, the temperatures were more even and relatively high, resulting in the temperatures of the vegetation season exceeding 1,7 and 1,3 degrees centigrade average for the years 1951-2009. Maize and sorghum, in spite of economical water management, they need a lot of water, especially under high temperature conditions, to demonstrate full yield potential [10, 18]. In the years of the tests the sum of precipitation was however high and exceeded the multiannual sum (by 95 mm in 2011; by 136 mm in 2012 and as much as 236 mm in extremely wet 2010. Despite such high rainfall, its distribution was not evenly distributed and in some periods there was a lack of moisture. It indicates the hydrothermal values below "1" (Figure 1). In 2010, the shortcomings emerged in June; in 2011 in May and August, September and October while in 2012 in September. The highest yields of maize were found in 2012, when the beginning of summer was wet and major water shortages occurred only in September. In 2011 the sorghum yields were the highest. but in the case of maize were also high. The year indicates that the sorghum was developing well even when the precipitation was not very high during the intensive growth period (VIII-IX) (Figure 1, Table 1 and 4). It confirms the thesis of good tolerance of both species, especially sorghum for periodic water shortages [2, 4, 10, 13].

Population of maize plants was close to the planned number of 9 pieces · m^{-2} while the average number of sorghum plants was about 15 pieces · m^{-2} and was nearly lower by 30% than the planned stock of 20.4 pieces.

Table 1. Weather conditions in the years 2010-2012 in Swadzim

Tab. 1. Warunki pogodowe w latach 2010-2012 w Swadzimiu

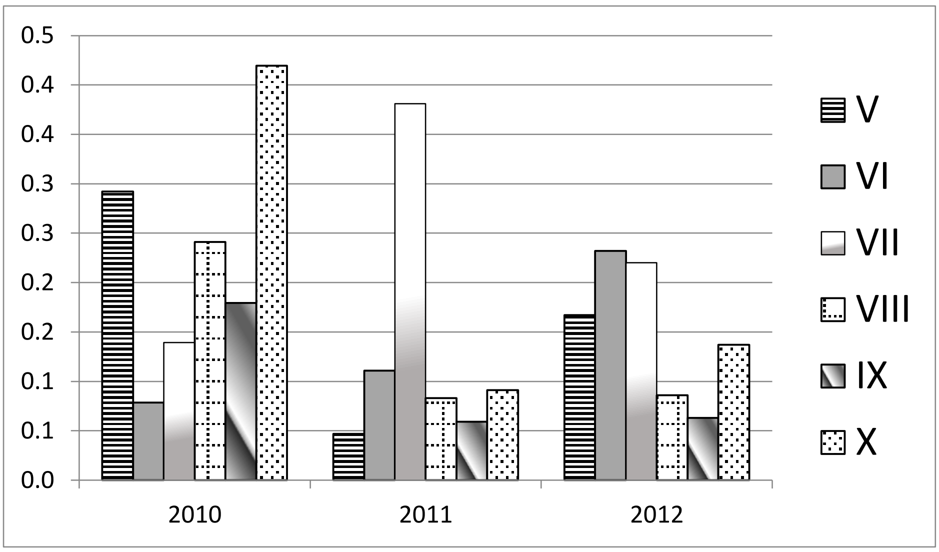
Month	2010	2011	2012	1951-2009
Terms of sorghum and maize sowing and harvesting				
Sowing time – maize - sorghum	29.04. 14.V.	29.04. 19.V.	28.04. 18.V.	-
Harvest time (sorghum + maize)	26.X.	21.X.	22.X.	-
Average air temperature ºC				
V	12,2	15,5	16,3	13,4
VI	18,4	19,9	17	16,7
VII	22,6	18,5	20	18,5
VIII	19,2	19,5	19,8	17,9
IX	13,0	15,9	15	13,6
X	7,0	9,8	8,6	8,8
V-X	15,4	16,5	16,1	14,8
Rainfall in mm				
V	110,5	22,5	84,4	52,3
VI	43,4	66,5	118,1	57
VII	97,5	218,7	136,2	72,2
VIII	143,5	50,4	52,7	56,9
IX	69,9	28,5	28,4	43,2
X	91,0	27,7	36,4	38,4
V-X	555,8	414,3	419,8	320

Source: own work / Źródło: opracowanie własne

In order to reduce the losses during the ensilaging, the dry matter content in the plants should be within the range of 30-35% [13, 16, 19]. The assumption is that maize is to compensate for too low content of dry matter in sorghum which is too low and is one of the limiting factors of its ensilaging [3, 7, 17, 19]. In own trials, as a result, under the conditions of the late harvest (beginning of the third decade of October) in years 2010 and 2012 the dry matter content the maize crop was above the recommended range and only in 2011 was about 30% (Table 2). For comparison, dry matter content in sorghum crop was about 26% in 2010 and 2012 and over 30% in 2011 [15]. In intercropping these species were complementary, giving the possibility of achieving average dry matter content of 30-35%.

It is worth emphasizing that the stems contain least dry matter, and cobs and leaves contain the most d.m. High content of d.m. in leaves is the result of late harvest. In synthetic terms, intercropping with sorghum did not affect the content of dry matter in maize however, the tendency to higher content of d.m. in stems at intercropped with sorghum cultivar Sucrosorgo 506. In view of the similarity of both maize varieties tested, differences in dry matter content in whole plants were not statistically significant (Table 3). The earlier Absolut variety contained slightly more dry matter in the leaves, while less in the stems.

Maize yields were relatively high at around 600 dt of green matter and over 200 dt of dry weight per hectare. There were significant differences in the years: in cooler and damp year 2010 the yields were the lowest: 473 dt of fresh matter and 204 dt of dry matter. The highest yields of fresh maize were recorded in 2011 (799 dt) and in dry matter the highest yields (250 dt·ha^{-1}) were obtained in 2012. Among the maize varieties tested, Absolut yielded slightly higher in 2010-11, in 2012 Vitras gave the higher yields. On average, yields of fresh and dry biomass of both varieties were not different (Tables 4-5). The intercropping of maize with sorghum resulted in only a slight decrease in fresh and dry weight compared to pure sowing. The reduction depended on the accompanying maize sorghum variety. Maize intercropping with GK Aron variant did not differ significantly from yield in pure sowing; in the case of mixcropping with Sucrosorgo 506 variant they were lower by 50 dt in fresh weight and by 15 dt on dry matter basis. It corresponded to a loss of 9,2% in fresh weight and by 7,3% in d.m. comparing to pure maize sowing (Tables 4-5). Slightly greater crop yields were observed in the case of the Absolut variety, but these differences were not confirmed by statistical analysis. Although no interaction was observed, it is interesting to note from the practical point of view that a variant of maize cultivar Vitras was slightly more competitive with sorghum.



Source: own work / Źródło: opracowanie własne

Fig. 1. Month hydrothermal coefficients in the growing seasons 2010-2012

Rys. 1. Miesięczne współczynniki hydrotermiczne w sezonach wegetacyjnych 2010-2012

Table 2. Dry matter content in maize plants depending on cultivars, sowing mode and years [%]
Tab. 2. Zawartość suchej masy w roślinach kukurydzy w zależności od odmian, sposobu siewu i lat [%]

	Sowing mode:	2010	2011	2012	2010-12
Whole plant	Pure sowing of maize	42,0	29,3	41,7	37,7
	Mix-cropping with GK Aron sorghum	43,6	29,0	42,5	39,0
	Mix-cropping with Sucrosorgo 506	44,4	29,4	43,7	39,2
	Average:	43,4	29,2	42,6	
	LSD 0,05	d.i.	d.i.	d.i.	d.i.
Cobs	Pure sowing of maize	59,6	49,5	60,6	56,6
	Mix-cropping with GK Aron sorghum	59,0	50,4	62,1	57,2
	Mix-cropping with Sucrosorgo 506	57,5	48,1	63,6	56,4
	Average:	58,7	49,3	62,1	-
	LSD 0,05	d.i.	d.i.	d.i.	d.i.
Stalks + Leves	Pure sowing of maize	32,0	21,8	28,5	27,4
	Mix-cropping with GK Aron sorghum	32,1	20,9	26,6	26,6
	Mix-cropping with Sucrosorgo 506	33,5	22,3	29,7	28,5
	Average:	32,5	21,6	28,3	-
	LSD 0,05	d.i.	d.i.	d.i.	1,81
Stalks	Pure sowing of maize	25,8	19,9	26,2	27,4
	Mix-cropping with GK Aron sorghum	26,6	19,3	25,4	26,6
	Mix-cropping with Sucrosorgo 506	27,3	20,9	28,7	28,5
	Average:	26,6	20,1	28,3	-
	LSD 0,05	d.i.	1,24	1,74	1,56
Leaves	Pure sowing of maize	48,0	25,0	37,0	36,7
	Mix-cropping with GK Aron sorghum	60,3	23,1	34,9	39,4
	Mix-cropping with Sucrosorgo 506	57,0	24,3	35,1	38,8
	Average:	53,1	24,1	39,7	-
	LSD 0,05	9,02	d.i.	1,74	d.i.

Source: own work / Źródło: opracowanie własne

Table 3. Dry matter content in maize plants depending on cultivars and years [%]
Tab. 3. Zawartość suchej masy w roślinach kukurydzy w zależności od odmian i lat

	Cultivar	2010	2011	2012	2010-12
Whole plant	Absolut	42,8	29,1	42,2	38,0
	Vitras	44,0	29,4	43,1	38,8
	LSD 0,05	d.i.	d.i.	d.i.	d.i.
Cobs	Absolut	59,5	51,4	59,8	56,9
	Vitras	58,0	47,3	64,4	56,5
	LSD 0,05	1,30	1,11	2,87	d.i.
Stalks+ Leaves	Absolut	31,2	20,9	28,8	26,9
	Vitras	33,9	22,4	27,9	28,1
	LSD 0,05	2,19	d.i.	d.i.	1,02
Stalks	Absolut	24,8	19,1	26,7	23,6
	Vitras	28,4	21,0	26,7	25,4
	LSD 0,05	2,32	1,39	d.i.	0,86
Leaves	Absolut	54,9	23,5	36,6	38,3
	Vitras	55,3	24,7	34,7	38,2
	LSD 0,05	d.i.	d.i.	d.i.	d.i.

Source: own work / Źródło: opracowanie własne

Comparing yields of maize with sorghum yields (described in earlier work [15], it should be noted that fresh matter yields obtained from both species were similar, but in dry matter were significantly higher in maize (227 vs. 188 dt·ha^{-1}). Among the sorghum varieties, lower yield is given by GK Aron and higher- by Sucrosorgo 506 (163 vs. 213 dt of d.m.) Similar results were obtained in other experiments where the Sucrosorgo 506 variety was distinguished by high yields, while other varieties yielded lower than 160 dt · ha-1 s.m. [5, 6, 10, 23].

The negative effect of mix-cropping was found in the case of GK Aron, which reacted with significant decreases in yield of fresh and dry matter, while Sucrosorgo 506, with higher plants and high biomass production, did not lower yields and was a stronger competitor for maize. It may be explained by the fact that the yields of maize intercropped with this variety were smaller than that of pure sowing, what was not observed in maize sown with the GK Aron (Tables 4-5).

Table 4. Fresh matter yields of maize plants depending on sowing mode and cultivars dt·ha^{-1} (2010-2012)
Tab. 4. Plony świeżej masy roślin kukurydzy w zależności od sposobu siewu i odmian w dt·ha^{-1} (2010-2012)

	A: Sowing mode:	B: Maize cultivars		Mean:
		Absolut	Vitras	
Yield in dt·ha^{-1}	Pure sowing of maize	646,9	619,1	633,0 a
	Mix-cropping with Aron sor-ghum	630,1	629,2	629,6 a
	Mix-cropping with Sucrosorgo 506	580,6	585,2	582,9 b
	Average:	619,2	611,2	-
	LSD 0,05	A = 19,01; B = d.i. A*B = d.i.		
Pure sowing = 100	Mix-cropping with Aron sor-ghum	96,7	101,0	98,9 a
	Mix-cropping with Sucrosorgo 506	88,8	92,8	90,8 b
	Average:	92,8	96,9	-
	LSD 0,05	A = 5,82; B = d.i. A*B = d.i.		

Source: own work / Źródło: opracowanie własne

Table 5. Dry matter yields of maize plants depending on sowing mode and cultivars in dt·ha^{-1} (2010-2012)
Tab. 5. Plony suchej masy roślin kukurydzy w zależności od sposobu siewu i odmian w dt·ha^{-1} (2010-2012)

	A: Sowing mode:	B: Maize cultivars		Mean:
		Absolut	Vitras	
Yield in dt·ha^{-1}	Pure sowing of maize	238,6	227,8	232,9 a
	Mix-cropping with Aron sorghum	230,1	236,8	233,4 a
	Mix-cropping with Sucrosorgo 506	211,4	224,4	217,9 b
	Average:	226,7	228,2	-
	LSD 0,05	A = 12,52; B = d.i. A*B = d.i.		
Pure sowing = 100	Mix-cropping with Aron sorghum	96,7	103,3	100,0 a
	Mix-cropping with Sucrosorgo 506	88,1	97,4	94,0 b
	Average:	93,8 b	100,7 a	-
	LSD 0,05	A = 8,68; B = 5,82 A*B = d.i.		

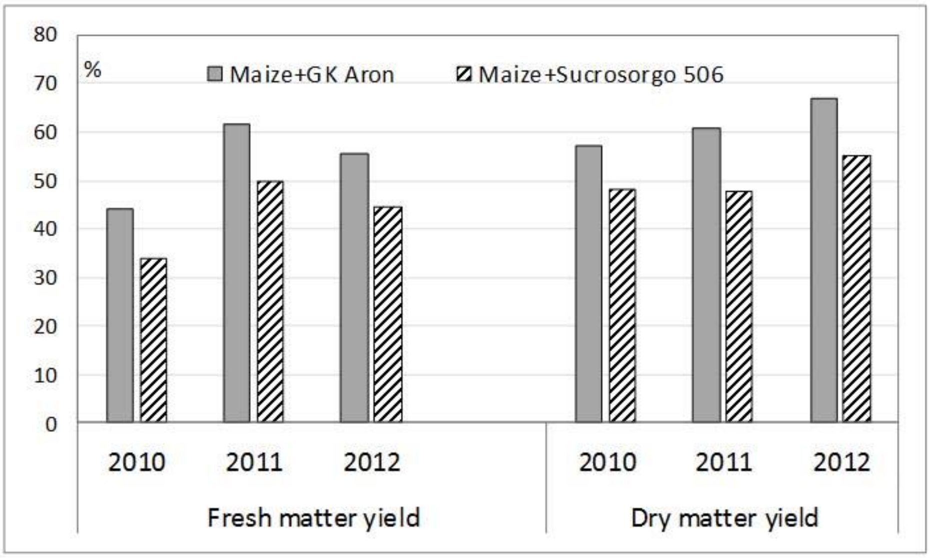
Source: own work / Źródło: opracowanie własne

Limiting crop yields in intercropping is associated with increased competition for light, nutrients and water and is dependent upon plant growth and height and shading. Large declines in yields in intercropping 1: 1 and 1: 2 were observed by Machul and Księżak [9], whereas in Kozłowski et al. [4] the yields in intercropping did not differ from the weighed average yield of both species in pure sowing.

Under conditions of mix-cropping, the final yield is determined by the share of the two components, i.e. maize and sorghum. On average, in three years' time, maize yield in fresh weight was 48.3%, but in dry matter in three years it was 52,7; 54., and 61,1%. This means that maize yielded higher than sorghum and it decided of final efficiency. It was found in 2012 (Figure 2), whereas in the wet and cooler year of 2010 the share of maize in the yield of fresh mass was on average 39%, but already 53% in d.m. It indicates that sorghum can be competitive for maize not only in steep conditions, but also in conditions of high August precipitation. In the working hypothesis, it was assumed that the accompanying maize variety of sorghum could have an impact on its development and yield. As is evident from Figure 2 each year there were significant differences in maize yields depending on the accompanying sorghum variety. Maize share in yield of d.m. from the sowing of the intercropping in the case of the crop with GK Aron variety was on average at 61,7% and only 50,3% in the sowing of Sucrosorgo 506. These differences were proved statistically. They were also very repetitive in years. The most predominance of maize appeared in 2012: in the crop with GK Aron it accounted for 67,0% of dry matter yield and by Sucrosorgo 506-55,2% of yield.

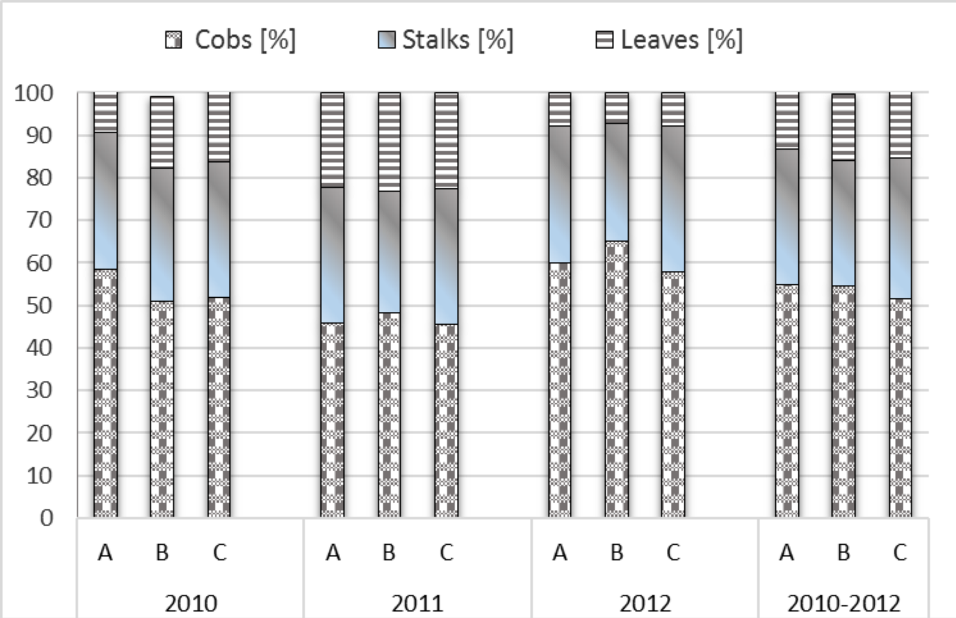
In addition to crop yield, qualitative factors contribute to the final value of the crop. In maize cultivation, the structure of plants is decisive, and above all the yield of cobs and their share in total yield [7, 12, 13, 19]. By maize intercropping with GK Aron sorghum there was found that the yields of cobs as well as their share in yield were similar to the results obtained in pure sowing (Table 6). In the case of the Sucrosorgo 506 crop, the yields of the cobs as well as their share in the dry matter decreased considerably. It shows that the selection of lower and higher sorghum varieties is a good indication of the mixed crop yield.

By analyzing the percentage of individual shoots in the collected biomass, it was found that a flask was the primary component of corn plants, accounting for about 37% of the wet crop but more than 50% of the dry matter weight (Table 7, Figure 3). These results indicate a significant difference in relation to sorghum, where the leading organ in shoot mass is stalk [3, 5, 15, 20, 22]. Sowing the maize alternately in two rows of Sucrosorgo 506 was resulted in a decrease in the share of flasks and an increase in the share of stems in the crop. Intercropping reduced the proportion of leaves in the fresh mass, also causing a tendency to increase their share in d.m. (Tab. 7). Even more clearly, it was noticeable in the percentage of leaves and stalks in the dry mass of the crop. Kruczek et al. [5] indicate that leaves' share diversification is due to different conditions.



Source: own work / Źródło: opracowanie własne

Fig. 2. Maize yields percentage in total yields in mix-cropping with two sorghum cultivars
Rys. 2. Udział plonu kukurydzy w plonie całkowitym w uprawie współrzędnej z dwoma odmianami sorgo



Source: own work / Źródło: opracowanie własne

Fig. 3. Maize plant structure depending on years and sowing mode 2010-2012 (A - pure sowing; B – with GK Aron; C – with Sucrosorgo 506)

Rys. 3. Struktura roślin kukurydzy w zależności od lat i sposobu zasiewu 2010-2012 (A – siew czysty; B – z GK Aron; C – z Sucrosorgo 506)

Table 6. Cobs yields and their percentage in whole plant yields depending on sowing mode 2010-2012

Tab. 6. Plony kolb i ich udział w plonie całych roślin w zależności od sposobu zasiewu 2010-2012

	Sowing mode	Yield of cobs [dt·ha^{-1}]	Rest of the plants [dt·ha^{-1}]	Percentage of cobs [%]
Fresh matter	Pure sowing of maize	224,4	408,6	36,6
	Mix-cropping with GK Aron sorghum	222,0	405,9	36,8
	Mix-cropping with Sucro-sorgo 506	200,0	382,9	35,8
	LSD 0,05	15,32	19,51	d.i.
Dry matter	Pure sowing of maize	127,5	106,4	54,8
	Mix-cropping with GK Aron sorghum	126,9	104,5	54,6
	Mix-cropping with Sucro-sorgo 506	113,2	104,8	51,6
	LSD 0,05	8,91	d.i.	2,57

Source: own work / Źródło: opracowanie własne

The structure of maize plants was significantly different in years. The biggest difference in plant structure in favor of pure sowing was obtained in 2010. In 2011 with high yields of green mass, the share of cobs was the smallest, with the largest share of leaves. Reverse proportions occurred in 2012 (Figure 3). The maize grown with GK Aron variety in 2011 and 2012 was characterized by an even better plant structure than pure sowing, i.e. a lower share of stems and leaves, and a higher share of flasks in dry matter yield.

Table 7. Maize plant structure depending on sowing mode and cultivars 2010-2012

Tab. 7. Struktura roślin kukurydzy w zależności od sposobu zasiewu i odmian 2010-2012

	Sowing mode / Maize cultivars	Stalk	Leaves	Cob
Fresh matter	Pure sowing of maize	45,1	17,2	36,6
	Mix-cropping with GK Aron sorghum	48,5	15,0	36,8
	Mix-cropping with Su-crosorgo 506	46,7	15,0	35,8
	LSD 0,05	2,80	0,87	d.i.
Dry matter	Pure sowing of maize	31,3	15,9	54,8
	Mix-cropping with GK Aron sorghum	28,3	16,4	54,69
	Mix-cropping with Su-crosorgo 506	32,3	16,7	51,6
	LSD 0,05	1,88	d.i.	2,57
Fresh matter	Absolut	46,1	17,3	36,4
	Vitras	47,4	15,4	36,4
	LSD 0,05	d.i.	0,69	d.i.
Dry matter	Absolut	29,1	17,2	54,2
	Vitras	32,2	15,5	53,0
	LSD 0,05	1,20	1,03	d.i.

Source: own work / Źródło: opracowanie własne

4. Conclusions

1. The tested maize cultivars Absolut and Vitras were characterized by a high biomass production - yielding about 600 dt of green mass and 210-240 dt of dry matter per hectare. It was accompanied by a high share of corn cobs, in the order of 52-55% of d.m.
2. The high and late variety of sorghum Sucrosorgo 506 in mixed sowing conditions, alternating in 2 rows, proved to be quite competitive in relation to maize. Coefficient of cultivation with the variety resulted in a decrease in maize yield by 9,2%, while in the case of dry matter the yield was

lower by 6% and 3% of share of the corn cobs, as compared to pure cultivating.

3. When cultivating with lower and less yielded cultivar of sorghum GK Aron, the structure of plants and maize yields were similar to these obtained in pure sowing.

4. Due to late harvest near 20 October, the dry matter content in maize yield was approximately 42% in the years 2010 and 2012 and 30% in 2011. This gave us the opportunity to obtain the recommended 30-35% of d.m. in the mixed yield of maize and sorghum.

5. Differences of maize cultivars in response to the intercropping with sorghum were small and variable in years. On average, cultivar Vitras proved to be slightly better in this respect.

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