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THE YIELDING AND BIOMETRICS OF BROAD BEAN DEPENDING ON THE APPLIED BIOLOGICAL PROTECTION

Summary

The aim of the thesis was to asseses the impact of biological protection on the yields and biometrics of broad bean, Windsor White variety. A field research was conducted in the years 2010-2012 in the Experimental Agricultural Farm in Prusy near Kraków. Double-factor experiments were conducted in the random blocks system in three repetitions on a very good wheat complex soil. The following five combinations of the biological protection of broad bean were compared in experiments. Based on the conducted research, it was found that years significantly diversified broad bean yields and biometrics. In 2011, with the most advantageous weather conditions, broad bean yielded the best; it had the highest number of seeds in a pod and, at the same time, the lowest number of sprouts in a plant. The most disadvantageous year, in these terms, was 2012 which was characteristic for the highest deficiency of precipitation. The compared protection combinations demonstrate that adding Polyversum WP biological preparation to seeds before sowing and the application of Bioczos BR agent on leaves twice or four times and Biosept 33 SL once contributes to the significant increase in broad bean yields. Whereas, the coordinate sowing of broad bean with coriander and fennel resulted in the drop in seeds yields, deteriorated yield structure parameters and biometric properties.
Keywords: *broad bean, yield, biological protection, coordinate sowing*

PLONOWANIE I CECHY BIOMETRYCZNE BOBU W ZALEŻNOŚCI OD ZASTOSOWANEJ OCHRONY BIOLOGICZNEJ

Streszczenie

Celem pracy była ocena wpływu biologicznej ochrony i biometrie bobu odmiany Windsor Biały. Badania polowe prowadzone w latach 2010-2012 w Rolniczym Gospodarstwie Doświadczalnym w Prusach k. Krakowa. Doświadczenie dwuczynnikowe prowadzono w układzie losowanych bloków w trzech powtórzeniach na glebie kompleksu pszennego bardzo dobrego. W doświadczeniu porównywano 5 kombinacji biologicznej ochrony bobu. W oparciu o przeprowadzone badania stwierdzono, że lata istotnie różnicowały plonowanie i biometrię bobu. W 2011 roku o najkorzystniejszym przebiegu pogody, bób istotnie lepiej plonował, wykształcił największą liczbę nasion w strąku i jednocześnie najmniejszą liczbę pędów w roślinie. Najbardziej niekorzystny pod tym względem okazał się 2012 rok, który odznaczył się największym niedoborem opadów atmosferycznych. Z porównywanych kombinacji biologicznej ochrony stwierdzono, że zaprawianie nasion przed siewem preparatem biologicznym Polyversum WP oraz aplikowanie nalistnie dwukrotnie lub czterokrotnie środka Bioczos BR i jeden raz Biosept 33 SL przyczyniało się do istotnego wzrostu plonowania bobu. Natomiast siew współrzędny bobu z kolendrą siewną i koprem włoskim powodował istotny spadek plonu nasion, pogorszył parametry struktury plonu i cech biometrycznych.
Słowa kluczowe*: bób, plon, biologiczna ochrona, siew współrzędny*

1. Introduction

Plant protection against pests is one of the main problems on ecological farms. There are few plant protection agents used for plants in this type of farms.

According to many authors [10, 19, 21], plant growth conditions and their yields may be improved through the use of various natural agents for plant protection against diseases, pests and weeds. In ecological agriculture preventive procedures are a basis for plant protection and they include: proper topography, correct crop rotation, good quality of sowing material, sowing rate, proper sowing date and other agrotechnical procedures. These procedures sometimes are not sufficient and it is necessary to control pathogenic factors or other pests additionally and directly. There are numerous researches concerning the impact of some biological preparations on the intensification of diseases and pests. According to Lipa and Pruszyński [10] and Sosnowska and Fiedler [17], appropriate and well-planned protection ought to be reflected in the plants yields size. Plant protection agents used in ecological agriculture may include, e.g. micro-organisms or plant origin compounds (essential oils, phenols, flavonoids and others). Apart from the varied content of these biopreparations, their main tasks consists, among others, in limitation of pests, protection of biodiversity and improvement of chemical, physical and biological properties of soil what contributes to the increase in yield and improvement of its quality [17, 20].

On ecological farms, mixed sowing or coordinate sowing, i.a. with herbs is also one of the methods of protecting plants against pests [2, 3, 6, 8, 9]. According to Senderski [14] and Stoyanowa [18], coriander is a herb which due to the high content of essential oils demonstrates high usability in plant protection. According to Silva and Domingues [13], coriander essential oil has an anti-microbe function. There are numerous researches on the significance and use of essential oils in plant protection (Gospodarek et al. [3], Wojciechowicz-Żytko [22]). According to Sobkowicz [16] and Leszczyńska and Cacak-Pietrzak [9], mixed sowing contributes to the increase in the plant genetic diversity in a community and it involves a better use of habitat factors and production space. Furthermore, plants cultivated in

mixed sowing yield better than those in pure sowing, and they reduce the number of pests [2, 8, 9, 23].

Broad bean (*Vicia faba L. ssp. maior Harz.*), like horse bean (*Vicia faba L. ssp. maior Beck.)* belong to the oldest species of plants cultivated in the world [5]. Broad bean seeds are a rich source of protein, glucose, vitamin C and pro-vitamin A. In literature there is little information about this plant species; there are considerably more data on horse bean, which is similar to broad bean – they belong to the same botanic family [4, 5]. The available references lack research on the impact of biological protection and coordinate broad bean cultivation on yield and biometrics.

The aim of the thesis was to assess the impact of biological protection on the yield and biometric characteristics of broad bean, Windsor White variety.

2. Material and methods

A field research was conducted in the years 2010-2013 at the Experimental Agricultural Farm in Prusy near Kraków. Double-factor experiments were conducted in the random blocks system in three repetitions on a very good wheat complex soil. The first factor included research years (2010, 2011, 2012) and the second factor- protection means (control, 4 treatments of biological protection, 6 treatments of biological protection, coordinate sowing: broad bean + coriander, broad bean + fennel). Land cultivation and fertilising was consistent with the ecological agriculture requirements and principles. Before sowing, biological preparation Polyversum WP was added to broad bean seeds, apart from the controlled object, in the amount of 10 g/kg seeds. The seeds were sown in the first decade of April at the depth of 6 cm in the spacing between rows 50 cm and in the row 10 cm. Coordinate plants (coriander - *Coriandrum sativum* L., fennel - *Foeniculum vulgare* Mill.) were sown in the amount of plants: 1/3 less than in pure sowing.

Broad bean in the vegetation period was protected against weeds by mechanical means. Diseases and pests were reduced by various biological protection combinations. The following combinations of the biological protection of broad bean were compared in experiments:

1. control (without seed treatment and on-leaf protection),
2. seed treatment with Polyversum WP + 2 x Bioczos BR + 1 x Biosept 33 SL,
3. seed treatment with Polyversum WP + 4 x Bioczos BR + 1 x Biosept 33 SL,
4. seed treatment with Polyversum WP, coordinate sowing of broad bean with coriander,
5. seed treatment with Polyversum WP, coordinate sowing of broad bean with fennel.

Biosept 33 SL in the dosage 2 l/ha was applied on leaves to reduce fungal diseases shortly before plants blooming. Bioczos BR, dose 4 blocks/1 l of water, was used when first aphids appeared and against diseases and bean weevil in the de-florescence period of the first floor of broad bean inflorescence. Dosing of this preparation was repeated every 7 days.

In seeds complete maturity, seeds yield was assessed from 1 m^2. On every 25 randomly sampled plants from each plot, the following measurements were carried out: the number of seeds in a pod, the number of pods in a sprout, the length of sprouts. All the results were subject to a variance analysis and the significance of differences was verified by Tukey's test at the level $\alpha = 0.05$.

3. Results and discussion

Weather conditions in the years of research (2010-2012) affected the broad bean yields and biometrics. According to Olszewska [12], leguminous plants, for their correct development, need from 300 to 450 mm of precipitation in the vegetation period. In own research, both the excess and deficiency in precipitation affected yields negatively (Table 1). Generally, in the research period, from April to July, 2010 may be regarded as highly humid (582.30 mm of precipitation) with an average air temperature 14.82°C, and 2012 as a warmer year (15.53°C) and the driest (299.30 mm of precipitation). Compared to the multiannual period, in 2010, May, June and July were characteristic for excessive humidity (Fig. 1). In the vegetation season under discussion, especially May had the highest sum of precipitation (294.60 mm) and was the coolest (on average 12.60°C).

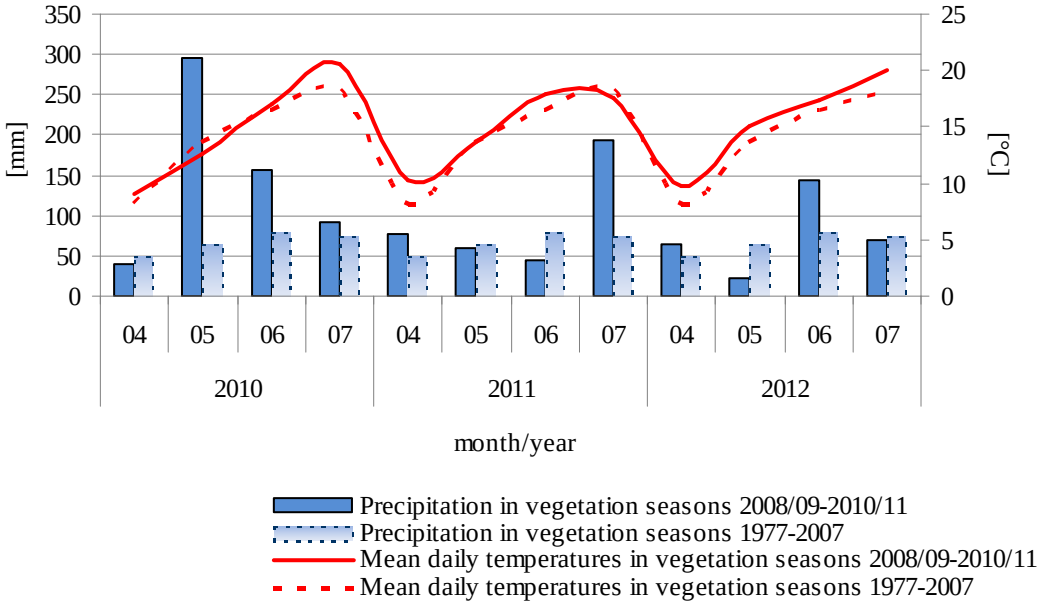
In general, weather conditions in 2010 contributed to the significant increase in the number of pods and the length of broad bean sprouts (Table 1). Whereas, in 2011, the annual precipitation from April to July was 377.40 mm and was closest to the optimal requirements for this plant species. However, April and July 2011 were characteristic for excessive humidity, in particular July, with recorded 194.40 mm of precipitation (Fig. 1). In this most humid month, the average air temperature was 17.57 °C and it was lower than in the multiannual period (18.19°C). The weather conditions in 2011 contributed to the significant increase in the seeds yield from 1 m^2 and the number of seeds in a pod, and plants, at the same time, formed significantly fewer sprouts (2 sprouts) than in 2012 (Table 1).
Whereas, the broad bean vegetation season 2012 was characteristic for humidity deficiency in May (22.80 mm of precipitation) and in July (68.70 mm of precipitation). In May, precipitation was three times lower than in the multiannual period (for this month). In 2012 humidity increase was recorded in June (143.10 mm of precipitation). In the period of own research, the highest humidity deficiency was in 2012 which significantly reduced broad bean seed yield from m^2, shortened the sprouts and, at the same time, the plants formed a significantly higher number of sprouts (4 sprouts). Similarly, Podleśny [13] demonstrated that the reduction in horse bean seed yields as a result of the drought may range from 20.1 to 72.7%.

As part of own research, in complete seeds maturity, broad bean seeds yield depended on the broad bean protection combination (Table 2). In K2 object, where seeds were treated before sowing with biological preparation Polyversum WP and Bioczos BR was applied on leaves twice, Biosept 33 SL was added once, there was the highest seeds yield. A similar broad bean yields level was recorded in K3 combination (seed treatment with Polyversum WP + 4 x Bioczos BR + 1 x Biosept 33 SL). Kulig at al. obtained analogous results [7] when testing ecological agents in horse bean protection. A positive impact of Kelpak (bioregulator) on plant yields was also determined by Matysiak and Adamczewski [11]. In own research, the significant lower yield from m^2 was obtained in the coordinate sowing combination of broad bean with coriander and fennel. A similar reaction was observed with the coordinate cultivation of horse bean with triticale [1]. Yet, Żabiński [23] has a different opinion while researching the coordinate sowing of lentil with buckwheat. In own research, the number of pods and seeds in a pod also depended on the broad bean biological protection combination (Table 2).

Table 1. Yield and biometric characteristics of broad bean in the research years (mean from the years 2010-2012)
Tab. 1. Plon i cechy biometryczne bobu w latach badań (średnia z lat 2010-2012)

A property examined	Years			Average	$NIR_{0.05}$
	2010	2011	2012		
Seeds yield ($g \cdot m^2$)	223.88	365.01	213.61	267.50	84.96
Number of seeds in a pod (pcs.)	2.61	3.53	2.31	2.82	0.52
Number of pods in one sprout (pcs.)	10.59	6.76	5.75	7.70	3.15
Number of sprouts in one plant (pcs.)	2.45	1.99	3.99	2.81	0.73
Length of sprouts (cm)	84.88	79.69	59.81	74.79	22.47

Source: own work/ Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 1. Weather conditions during broad bean growing season according to Meteorological Station in Prusy near Krakow
Rys. 1. Warunki pogodowe w okresie wegetacji bobu wg Stacji Meteorologicznej w Prusach k. Krakowa

Table 2. Yielding of the broad bean depending on the applied biological protection
Tab. 2. Plonowanie bobu w zależności od kombinacji biologicznej ochrony

Plant protection combination	Yield seeds ($g \cdot m^2$)	Number of seeds on pods (item)	Number of pods on stem (item)
K1	273.24	2.79	8.34
K2	320.02	3.01	7.74
K3	309.83	2.87	8.77
K4	214.52	2.77	5.98
K5	219.90	2.64	7.67
Mean	267.50	2.82	7.70
$LSD_{0.05}$	86.87	0.30	2.36

K1 - control (without seed treatment and on-leaf protection), K2 - seed treatment with Polyversum WP + 2 x Bioczos BR + 1 x Biosept 33 SL, K3 - seed treatment with Polyversum WP + 4 x Bioczos BR + 1 x Biosept 33 SL, K3 - seed treatment with Polyversum WP, K4 - seed treatment with Polyversum WP, coordinate sowing of broad bean with coriander, K5 - seed treatment with Polyversum WP, coordinate sowing of broad bean with fennel *Source: own work / Źródło: opracowanie własne*

The applied protection in K2 combination (seed treatment with Polyversum WP + 2 x Bioczos BR + 1 x Biosept 33 SL) contributed to the significant increase in the quantity of seeds in a pod but only with reference to broad bean in the coordinate cultivation with fennel. In the remaining objects, broad bean formed the quantity of seeds in a pod on a comparable level. Among the analysed objects of broad bean biological protection, the formation of sprouts was considerably facilitated by the combination in which seeds were treated with Polyversum WP and in the vegetation period the following agents were applied on leaves: 4 x Bioczos BR and 1 x Biosept 33 SL (K3). The coordinate cultivation of broad bean with coriander significantly reduced the quantity of pods from one plant sprout but with reference to control only. This protection method reduced the quantity of pods and seeds in a pod. Białkowska et al. [1] determined a similar dependence in the coordinate cultivation of horse bean with triticale. Own research demonstrated the lack of any significant differences between the combinations of biological protection and the quantity and the length of stem (Table 3).

Table 3. Number and the length of stems on broad bean depending on the biological protection applied
Tab. 3. Liczba pędów i długość pędów bobu w zależności od kombinacji ochrony biologicznej

Plant protection combination	Number of stems (item)	Length of stem (cm)
K1	2.99	77.76
K2	2.94	74.77
K3	2.86	74.59
K4	2.45	73.48
K5	2.79	73.37
Mean	2.81	74.79
$LSD_{0,05}$	n. s.	n. s.

n.s. – non significant *Source: own work / Źródło: opracowanie własne*

K1 - control (without seed treatment and on-leaf protection), K2 - seed treatment with Polyversum WP + 2 x Bioczos BR + 1 x Biosept 33 SL, K3 - seed treatment with Polyversum WP + 4 x Bioczos BR + 1 x Biosept 33 SL, K3 - seed treatment with Polyversum WP, K4 - seed treatment with Polyversum WP, coordinate sowing of broad bean with coriander, K5 - seed treatment with Polyversum WP, coordinate sowing of broad bean with fennel

4. Conclusion

From one year to the next broad bean yields and biometrics were significantly diversified. In 2011, with the most advantageous weather conditions, broad bean yielded the best; it had the highest number of seeds in a pod and, at the same time, the lowest number of stems in a plant. The most disadvantageous year, in these terms, was 2012 characterized by the highest deficiency of precipitation. The most disadvantageous year, in these terms, was 2012 which was characteristic for the highest deficiency of precipitation. The compared protection combinations demonstrate that adding Polyversum WP biological preparation to seeds before sowing and application of Bioczos BR agent on leaves twice or four times and Biosept 33 SL once contributes to the significant increase in broad bean yields. Whereas, the coordinate sowing of broad bean with coriander and fennel resulted significant decrease in seeds yields, deteriorated yield structure parameters and biometric properties.

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