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EVALUATION OF WEED INFESTATION IN FABA BEAN DEPENDING ON IRRIGATION, TILLAGE SYSTEM AND MINERAL FERTILIZATION

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Abstract

The field experiment was carried out in 2004-2006 in Chlebówko localized 20 km from Stargard Szczeciński and 5 km north-east from Stara Dąbrowa commune – 53°27'N and 15°10'E. The area is elevated 62-72 m above mean se level (ASL). The influence of irrigation, tillage system, and NPK mineral nutrition on weed infestation of faba bean variety 'Titus' with determined development rate, was evaluated. The weed infestation degree in the faba bean plantation depended on moisture conditions, fertilization rates, and tillage system. Irrigation increased the number, fresh weight, and dry matter of weeds, respectively by 92%, 130%, and 138%. Likewise, increasing nutrition elevated values of these parameters by 46%, 80%, and 95%. The tillage simplifications enhanced the weed population, particularly on irrigated and fertilized objects. Irrigation, mineral nutrition, and simplified tillage caused compensation of spring, winter and perennial weed species on plantation of faba bean 'Titus'. *Chenopodium album*, *Stellaria media*, and *Polygonum convolvulus* predominated on studied plots.

Key words: irrigation, tillage system, fertilization, weed infestation, faba bean

INTRODUCTION

Precipitation shortage and its distribution are one of the main factors limiting the possibilities for growing and yielding legumes in Poland. Divergence of precipitation during the growing season causes that practically in each of them there are shorter or longer drought periods, the adverse effects of which can be reduced by supplementary irrigation (Karczmarczyk 2006, Podsiadło 2001, Podsiadło and Karczmarczyk 2003, Rokosz and Podsiadło 2015).

Out of this group of plants, the faba bean plant is characterized by the highest yielding potential, but also the highest water and nutrients requirements. In years with high precipitation deficiency through irrigation, the increase in seed yield on light soils, may exceed 50% (Dudek *et al*. 2013, Gawrońska-Kulesza 2005, Szukała *et al*. 2007).

In order to achieve high production efficiency, besides supplying plants with nutrients through mineral fertilization, it is necessary the proper soil preparation for sowing. Results of the up-to-date experiments vary. According to some authors, the tillage system significantly influences on the growth and development of faba bean (Dzienia *et al*. 1995, Marks and Nowicki 1997). There are data indicating that simplified tillage and direct sowing, as compared to conventional cultivation, do not reduce the yield of lupine seeds (Księżak and Szukała 2015). According to Rokosz and Podsiadło (2015), the use of simplifications in the tillage of faba bean to a greater extent limits the yield of a traditional cultivars than the self-completing one. Likewise, the reduction in soybean yield, as a result of simplified tillage systems, was recorded by Bujak *et al*. (2001).

There is no doubt that both the improvement of soil moisture and nutrient content, as well as the use of different tillage systems significantly shape the type and degree of weed infestation in a crop (Anderson 2004, Chokor *et al*. 2008, Faligowska and Szukała 2008, Gawęda 2007, Podsiadło 2001).

The purpose of the research was to determine the effect of irrigation, tillage system, and mineral fertilization on the weed infestation in the canopy of faba bean cultivated on light soil with varying rate of growth and development.

MATERIAL AND METHODS

The field experiment was carried out in 2004-2006 in Chlebówko localized 20 km from Stargard Szczeciński and 5 km north-east from Stara Dąbrowa commune – 53°27'N and 15°10'E. The elevation of the experiment site is 62-72 m above mean se level (ASL).

The faba bean variety 'Titus' with determined development rate was evaluated. The experiments were established in the dependent pattern by means of split-plot-split-block method in four replicates. The harvest plot area was 16 m^2.

Three factors were applied: irrigation with non-irrigated (O) and irrigated objects (W). Duration of this treatment was determined by the tensiometric method when the water potential of the soil was reduced to 0.01 MPa. Another factor was the tillage system – traditional, simplified and direct sowing. In the simplified system, no post-harvest nor pre-winter tillage was used, but only the aggregate in pre-sowing tillage. The third factor was mineral fertilization NPK, control (0NPK) – no fertilization, 1NPK – 120 kg·ha^{-1} (20+40+60), 2NPK – 240 kg·ha^{-1} (40+80+120), 3NPK – 360 kg·ha^{-1} (60+120+180).

Winter wheat was a forecrop. The whole tillage and nursing was done according to generally used agrotechnical principles. Faba bean seeds were inoculated Rhizobium bacteria. Prior to harvesting, the number of fresh and dry warts was determined on the roots of the Faba bean

The experiment was established on the brown leached soil developed from light loamy sand and weakly loamy sand (5 Bw pgl:ps) qualified to good rye complex and quality class IV b. This soil type is characterized by humus content of about 2-3%, neutral to alkaline pH (6.5-7.6), low concentrations of available forms of P (58-76 g·kg^{-1}) and K (94-124 g·kg^{-1}). The ground water level can be found below 4m.

Suma opadów wegetacyjnego sezonu, od kwietnia do września, we wszystkich latach doświadczeń, była niższa od danych z wielolecia oraz od optymalnych potrzeb opadowych tego gatunku, natomiast średnia temperatura powietrza była wyższa od wieloletnich danych. Dawki nawadniania, zastosowane w okresie od maja do lipca, wyniosły od 90 do 130 mm.

From April to September, in all years of experience, it was lower than the data from many years and the optimum rainfall needs of this species, while the average air temperature was higher than the long-term data. Irrigation doses applied between May and July ranged from 90 to 130 mm. A detailed description of the precipitation and thermal conditions, as well as dates and doses of irrigation in individual years of experiment, can be found in previous work of the authors (Rokosz and Podsiadło 2015).

The weed infestation was assessed in all years of study and on each experimental plot before harvest. The assessment was carried out by botanical-weight method using a frame of 0.5 m^2 area. The number and species composition, fresh and dry matter of weeds were calculated, as well as biological groups and dominant species were distinguished.

Subsequently, the study results were statistically processed using variance analysis, and the difference significance between mean values was calculated applying Tukey test at the significance level of 0.05.

RESULTS AND DISCUSSION

In present experiment, a significant influence of all experimental factors on weed infestation was recorded (Table 1).

Irrigation caused a remarkable increase in the number, dry matter, and fresh weight of weeds in the canopy of 'Titus' cv. by 92%, 130%, and 138%, respectively.

Table 1. Influence of irrigation, tillage system and fertilization on the number [pcs.], fresh weight, and dry matter [g] of weeds (mean values for years)

Treatments		Number	Fresh weight	Dry matter
Irrigation	O*	12,3	197,2	93,4
	W	23,6	454,4	222,4
Tillage system	traditional	12,2	179,9	80,4
	reduced tillage	19,2	382,3	184,6
	direct sowing	22,5	415,2	208,9
Fertilization	0NPK	13,8	233,2	108,6
	1NPK	16,9	290,5	138,7
	2NPK	21,0	360,4	173,1
	3NPK	20,2	419,1	211,4
$LSD_{0,05}$ for:				
Irrigation		6,3	152,7	70,7
Tillage system		1,3	49,2	24,3
Fertilization		1,7	42,5	26,2

* – non-irrigated (O) and irrigated objects (W)

According to Dzieżyc (1988), irrigation and high fertilization levels contribute to the increase of crop yields and to the reduction of its weed infestation. In the well-fertilized canopy, water and light conditions deteriorate for weeds that are more severely degraded. However, it should be borne in mind that in some cases, fertilization and irrigation can increase the weed infestation. This refers to situations, in which the growth rate of a crop is slower than that of the weeds, and the light, water and nutrient conditions favor development of the latter, as it was in the case of our own studies.

Own studies have also shown an increase in the number, fresh weight, and dry matter of weeds under conditions of supplementary irrigation and high mineral fertilization, which was fully confirmed by Rolbiecki *et al*. (2001).

The tillage system is one of the undoubtedly important factors shaping the weed community in the crop growing (Kubik-Komar *et al*. 2004).

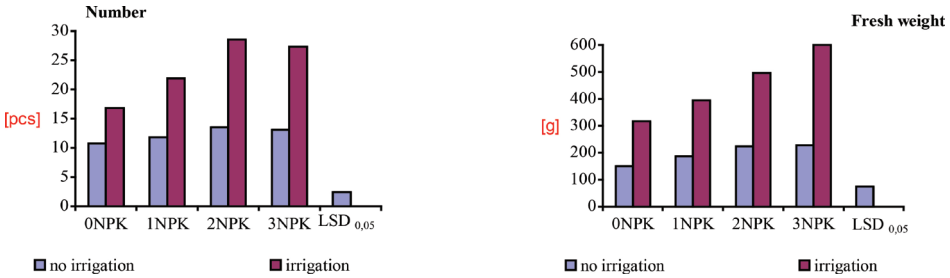

Figure 1. Impact of irrigation and fertilization on the number and weight of weeds (mean values for years)

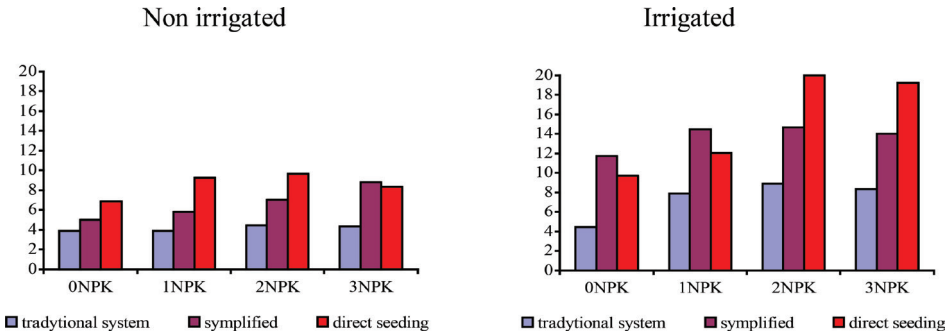

Figure 2. Impact of irrigation, tillage system and fertilization on the number of spring weed species [pcs.] (mean values for years)

In the simplified system, the number, fresh weight, and dry matter of weeds increased as compared to traditional tillage (Table 1). Objects with direct sowing were the most heavily infested by weeds. The increase in the number, fresh weight, and dry matter of weeds, as compared to traditional cultivation, was 84%, 131%, and 160%, respectively.

These results are consistent with those reported by Dzienia *et al*. (2001a), who recorded an increase of weed infestation of legumes, cereals, and root crops under conditions of simplified tillage. Similarly, in another work, Dzienia *et al*. (1995), achieved the increase in the faba bean canopy by 40% in objects with the plowless tillage and direct sowing in relation to traditional tillage. On the other hand, the highest weed dry matter of about 127% was found on plots with plowless tillage. Goosefoot (*Chenopodium album*) was a dominating weed.

The number, fresh weight, and dry matter of weeds also increased as a result of increasing the fertilization dose reaching the highest value at the level

of 3NPK (360 kg NPK·ha^{-1}) by: 46%, 80%, 95%, as compared to the control (Table 1).

There was significant interaction of irrigation and mineral fertilization in shaping the number and weight of weeds (Figure 1).

The weed number increased both on plots with irrigation and without this treatment, while fertilized with 240 kg NPK·ha^{-1} (2NPK) by 69% and 26%, whereas decreased at the level of 3NPK. Along with the fertilization level increase up to 3NPK, elevated contents of weed fresh weight by 53% and 92% as well as dry matter by 59% and 112%, were recorded in objects with and without water application. A combined effect of irrigation and fertilization using 360 kg NPK·ha^{-1} increased the number and fresh weight of weeds respectively by 153% and 308%.

Large compensation of spring, winter and perennial weeds (Figures 2, 3 and 4) was found in 'Titus' faba bean canopy.

Number of spring weed species arose in non-irrigated and irrigated objects in all tillage systems with increasing the fertilization rates (Figure 2).

Winter weeds composed another group observed in 'Titus' faba bean canopy.

Application of irrigation, high fertilization rates, and simplified tillage systems increased the number of species of this biological group of weeds (Figure 3).

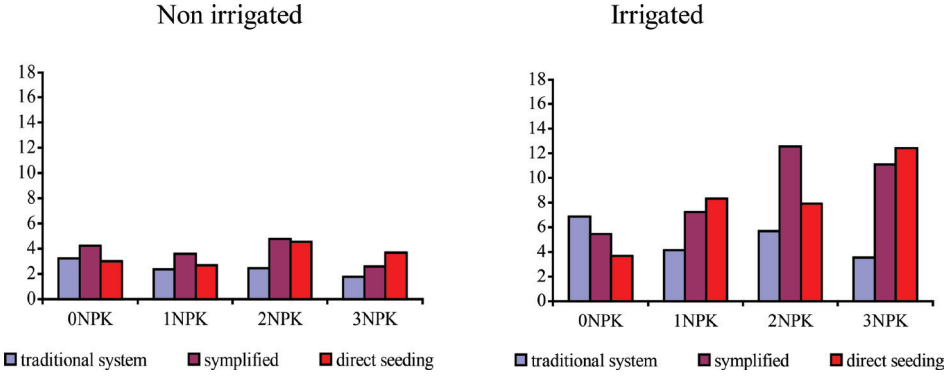

Figure 3. Impact of irrigation, tillage system, and fertilization on the number of winter weed species [pcs.] (mean values for years)

The increase in the mineral fertilization level in traditional tillage and the use of irrigation reduced the number of perennial weed species. On the other hand, a remarkable increase in the number of this weed group was found in both water variants, both in the simplified tillage and direct sowing system (Figure 4).

A comprehensive co-operation of irrigation with mineral fertilization has increased the number of spring, winter and perennial weed species, the most in

direct sowing and simplified tillage, while the least in conventional tillage as compared to the control (Figures 2, 3 and 4).

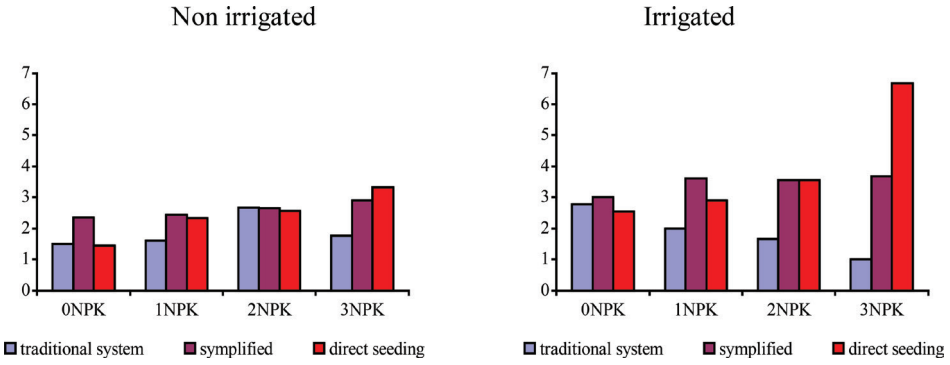

Figure 4. Impact of irrigation, tillage system, and fertilization on the number of perennial weed species [pcs.] (mean values for years)

Among segetal species, goosefoot (*Chenopodium album)*, chickweed *(Stellaria media*), and wild buckwheat (*Polygonus convolvulus*) predominated in 'Titus' faba bean canopy (Figures 5, 6, and 7).

Weed infestation due to the goosefoot *(Chenopodium album)* has increased in both irrigated variants along with the fertilization rate increase in traditional tillage. In simplified method, the quantity of this species increased at a high level of fertilization on plots without water, while decreased with water. Number of goosefoot arose in non-irrigated objects with direct sowing up to the level of 2NPK, whereas in irrigated one – to 3NPK (Figure 5).

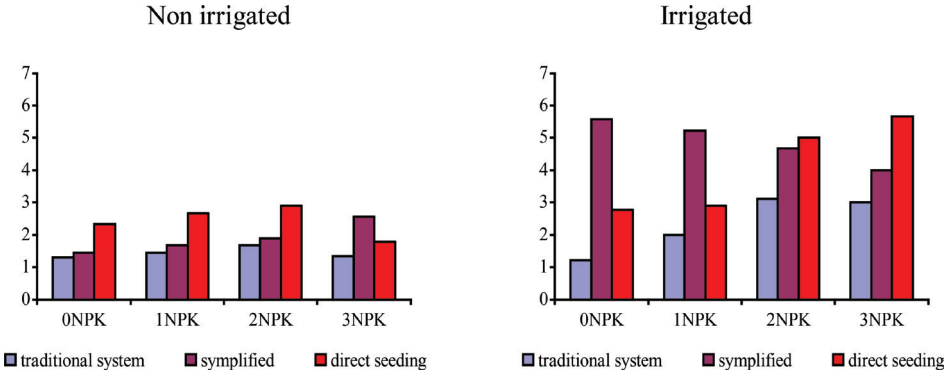

Figure 5. Impact of irrigation, tillage system, and fertilization on the number of *Chenopodium album* [pcs.] (mean values for years)

The population of wild buckwheat (*Polygonus convolvulus*) increased on irrigated and non-irrigated plots at the increased fertilization rates for all tillage variants (Figure 6).

In the case of traditional tillage system, a large amount of that species was recorded at 1NPK nutrition level, both on non-irrigated and irrigated objects. Mineral fertilization applied at the dose of 240 kg NPK·ha^{-1} caused the largest arise in chickweed plants *(Stellaria media*) number on irrigated and non-irrigated plots at simplified tillage. Treatment using 240 kg NPK·ha^{-1} in non-irrigated, as well as 120 kg NPK·ha^{-1} in irrigated objects the most strongly compensated this species development in objects with direct sowing (Figure 7).

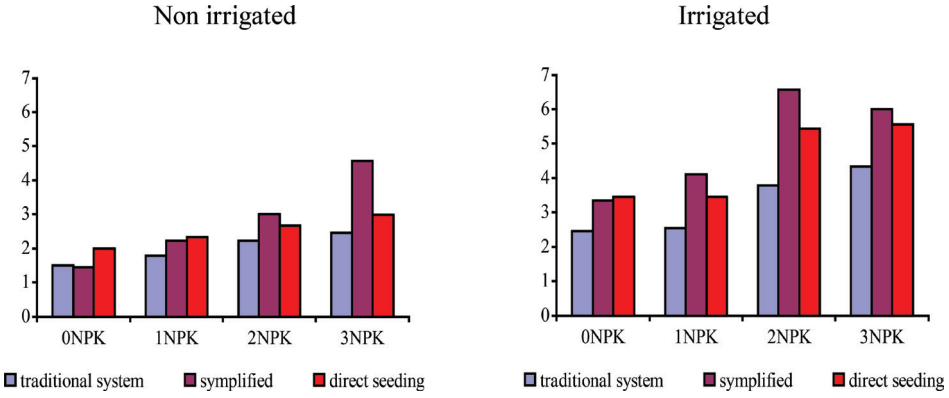

Figure 6. Impact irrigation, cultivation system and fertilization on the numbers *Polygonus convolvulus* [pcs.] (average of the years)

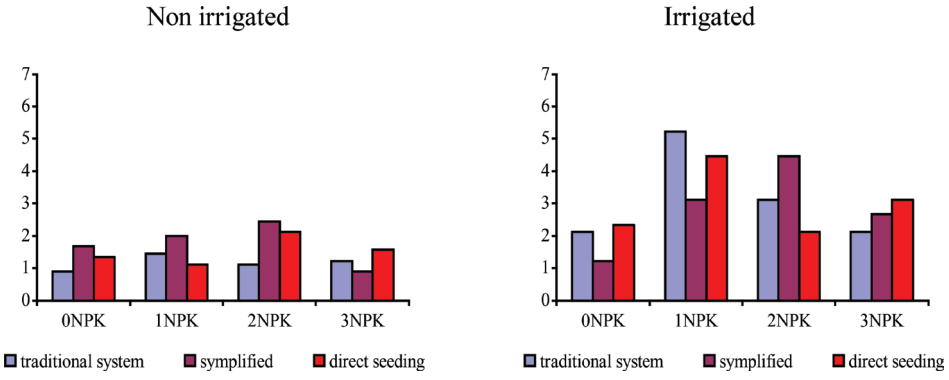

Figure 7. Impact of irrigation, tillage system, and fertilization on the number of *Stellaria media* [pcs.] (mean value for years)

Regarding to 'Titus' cv., higher number of *Chenopodium album*, *Stellaria media*, and *Polygonus convolvulus* in traditional and simplified tillage as well as direct sowing as compared to the control, was observed, which resulted from the combined treatment of irrigation and mineral nutrition. The tillage simplifications under conditions of irrigation and high fertilization rates favored the appearance of these weeds species, while the treatments to a lesser extent resulted in a traditional tillage (Figures 5, 6, and 7).

Dzienia and Wrzesińska (2001) reported that giving up the plowing favored perz development in faba bean canopy, and its peak growth was observed in plowless tillage system. The tillage systems did not differentiate remarkably the weed infestation due to annual species, nevertheless the number and weight of perennial weeds increased along with simplifications. It also affected the increase in the percentage of goosefood (*Chenopodium album*).

Malicki *et al*. (2000) in studies upon faba bean, winter wheat, and spring barley grown in three tillage systems, have found that the plowing favors the species diversity of spring short-term weeds, whereas simplifications, namely direct sowing, contributes to their compensation.

CONCLUSIONS

1. The weed infestation degree in the faba bean plantation depended on moisture conditions, fertilization rates, and tillage system.
2. Irrigation, increased NPK mineral fertilization and simplified cropping system cause an increase in the number and weight of weeds in field bean plantings.
3. The use of irrigation, increased mineral fertilization and a simplified cropping system increases the number of spring, winter and perennial weeds.
4. *Chenopodium album*, *Stellaria media*, and *Polygonus convolvulus* predominated on studied plots.

REFERENCES

Anderson R.L. (2004). *Impact of subsurface tillage on weed dymamics in the Central Grein Plains*. Weed Tech. 18, 1: 186–192.

Bujak K., Jędruszczak M., Frant M. (2001). *Wpływ uproszczeń w uprawie roli na plonowanie soi*. Biuletyn Instytutu Hodowli i Aklimatyzacji Roślin. Nr 220: 263-300.

Chokor J.U., Ikuenobe C.E., Akaelu I.A. (2008). *The effect of tillage and herbicides (Rimsulfuron and Codal Gold) on weed regeneration.* Inter. J. Soil Sci.. 3: 164–168.

Dudek S., Kuśmierek-Tomaszewska R., Żarski J., Szterk P. (2013). *Ocena potrzeb deszczowania bobiku w warunkach zróżnicowanego nawożenia azotowego*. Infrastruktura i Ekologia Terenów Wiejskich, 1,II: 25-35.

Dzienia S., Piskier T., Wereszczaka J. **(**1995). *Reakcja pszenżyta ozimego na siew bezpośredni*. Konf. Nauk. "Siew bezpośredni w teorii i praktyce" Szczecin Barzkowice: 49-55.

Dzienia S., Wrzesińska E. (2001). *Fitocenoza łanu bobiku w warunkach zróżnicowanej uprawy roli*. Post. Ochr. Roślin. 41 (1): 323 — 329.

Dzieżyc J. (1988). *Rolnictwo w warunkach nawadniania*. PWN Warszawa: 438.

FaligowskaA., Szukała J. (2008). *Wpływ systemów uprawy roli i zachwaszczenia łubinu żółtego i wąskolistnego*. Progres in Plant Protection, 49 (1): 343-347.

Gawęda D., (2007). *Wpływ systemów uprawy roli na zachwaszczenie soi*. Acta Agrophysica, 10 (1): 59-67.

Gawrońska-Kulesza A., Lenart S., Suwara I. (2005). *Wpływ zmianowania i nawożenia na zachwaszczenie łanu i gleby*. Fragm. Agron. 22(2): 53–62.

Karczmarczyk S. (2006). *Nawadnianie roślin pastewnych*.. Rozdział w pracy zbiorowej Nawadnianie roślin red. S. Karczmarczyk i Nowak L. PWRiL Poznań: 409-411.

Księżak J., i Szukała J. (2015). *Ważniejsze elementy agrotechniki roślin strączkowych*. Rozdział w pracy Wybrane zagadnienia uprawy roślin strączkowych, red. Księżak J.. FAPA: 17-27.

Kubik-Komar A., Jędruszczak M., Wesołowska-Janczarek M. (2004). *Ocena zmian w zbiorowisku chwastów pszenicy ozimej pod wpływem sposobów uprawy roli z zastosowaniem wielowymiarowych metod statystycznych.* Fragm. Agron. 1(81): 42-55.

Malicki L., Podstawka-Chmielewska E., Kwiecińska E. (2000). *Fitocenoza łanu niektórych roślin na rędzinie*
w warunkach zróżnicowanej uprawy roli. Fragm. Agron. 17(2): 30–44.

Marks M., Nowicki J. (1997). *Reakcja bobiku na różne sposoby uprawy roli*. Zesz. Probl. Post. Nauk Rol. 446: 193–197.

Podsiadło C. (2001). *Studia nad deszczowaniem i nawożeniem mineralnym bobiku, grochu siewnego, łubinu białego i łubinu żółtego, uprawianych na glebie lekkiej*. Rozprawy. AR Szczecin 203: 102.

Podsiadło C., Kaczmarczyk S. (2003). *Ocena wpływu deszczowania i nawożenia mineralnego na plonowanie*
i zachwaszczenie łubinu wąskolistnego. Zesz. Probl. Post. Nauk Rol., 495: 191-200.

Rokosz E., Podsiadło C. (2015). *Wpływ deszczowania, systemu uprawy i nawożenia mineralnego na plonowanie i właściwości fizyczne gleby lekkiej w uprawie odmian bobik.* Infrastruktura i Ekologia Obszarów Wiejskich. III/1: 625-636.

Rolbiecki S., Żarski J., Dudek S. (2001). *Wpływ deszczowania i nawożenia azotem na zachwaszczenie upraw na glebie bardzo lekkiej*. Zeszyty Naukowe ATR Bydgoszcz 236, Rolnictwo 47: 121-128.

Szukała J., Czekała J., Maciejewski T., Jakubus M. (2007). *Wpływ współdziałania uproszczeń uprawy roli, deszczowania i nawożenia na plonowanie i jakość nasion bobiku*. Zesz. Probl. Post. Nauk. Roln., 522: 351-360.

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