ACTA AGROBOTANICA
Vol. 66 (4), 2013: 165–172
Original Research Paper
DOI: 10.5586/aa.2013.063

# *Consolida regalis* Gray SEED PRODUCTION AS INFLUENCED BY THE HABITAT AND CROP PLANT IN THE WESTERN PODLASIE REGION

**Teresa Skrajna, Maria Ługowska, Janina Skrzyczyńska**

Department of Agricultural Ecology University of Natural Sciences and Humanities
B. Prusa 14, 08, 110 Siedlce
e-mail: tskrajna@op.pl

Received: 15.03.2013

A b s t r a c t

Studies were conducted in 2007–2009 in the Western Podlasie region to examine the seed production potential of *Consolida regalis* under different habitat conditions. *Consolida regalis* populations from 15 sites representing the habitat amplitude of this species were examined. Thirty morphologically different plants were sampled from each habitat and soil samples were taken to determine soil contents of available phosphorus (P), potassium (K) and magnesium (Mg) as well as pH. The results were statistically analysed.

The seed production potential of the species studied was most strongly correlated with soil contents of magnesium (Mg), potassium (K), phosphorus (P) and soil pH. By contrast, the kind of crop plant and its cover were insignificant. Of the plant characteristics, plant height and traits associated with inflorescence structure had a significant influence on seed production potential. The populations with the greatest seed production potential produced an average of 1287 and 965 seeds per plant. These populations were associated with the most fertile sites (good wheat soil complex) where the differences in seed production potential resulted from the nutrient contents and soil pH. By contrast, the least seeds were produced by plants growing on poor and acidic light soils. The average seed number per plant ranged from 42 to 83. Low concentrations of the nutrients examined were determined, with the soil content of magnesium being very low.

**Key words:** *Consolida regalis*, seed production, winter cereals, stubble fields, Western Podlasie region

## INTRODUCTION

Weeds are characterised by a very high seed production potential which is crucial for their survival under the conditions of high anthropological pressure. They can produce millions of seeds per plant [1,2] and their seed production potential is much higher that the generative reproduction of crop plants. Seed production potential is a species-specific characteristic which is also influenced by certain habitat conditions such as soil density, kind of crop plant and conditions within the stand (crop plant density) [1–3], in a stubble field [4] or fallow [5]. It may be of interest to find out what the effect of selected habitat factors on the amount of *Consolida regalis* seeds set and produced is, as the species is characterised by various threat levels at national and regional scales [6]. There has recently been observed diminished soil fertility of sites with this species in the study area, whereas in Lower Silesia an occurrence of *Consolida regalis* dropped by as much as 40% [7]. The objective of the study was to determine *Consolida regalis* seed production potential in winter cereal crops and stubble fields under different habitat conditions as related to soil nutrient abundance and crop plant density.

## MATERIALS AND METHODS

The studies were conducted from 2007 to 2009 in the Western Podlasie region. They included *Consolida regalis* populations infesting crop plants and stubble fields belonging to agricultural complexes of various soil quality. A total of 15 sites representing soils preferred by this plant were selected to obtain plants (Table 1) (Fig. 1). The soil unit was determined based on agricultural soil maps at a scale of 1:5000.

In order to record the lowest and highest seed production, 30 morphologically diversified plants were sampled from each site; the overall number of sampled plants was 450. Population potential in the sites studied

was determined based on the average seed number per mature follicle (seeds were counted in all mature follicles for each plant). It was assumed that immature follicles would develop seeds able to sprout before harvest. Due to seed falling and uneven seed maturing, only plants in which 50% of seeds were at the stage of milk to dough maturity (around two weeks before cereal harvest and 5–6 weeks after harvest in stubble fields) were sampled. At each site soil samples were taken from the plough layer to determine pH in KCl, available phosphorus (P), potassium (K) and magnesium (Mg) contents. Chemical analyses were performed at a certified laboratory of the National Chemical and Agricultural Station in Warsaw. The results were statistically analysed [8]. Variation coefficients were calculated for the average seed number per site. In order to determine the significance of differences in seed production potential of the study sites, the Kruskal-Wallis test, which is a non-parametric equivalent of ANOVA, was used at $p \leq 0.05$. The strength of association between seed production potential, habitat conditions studied and selected morphological characteristics were examined using the Spearman's rank correlation coefficient.

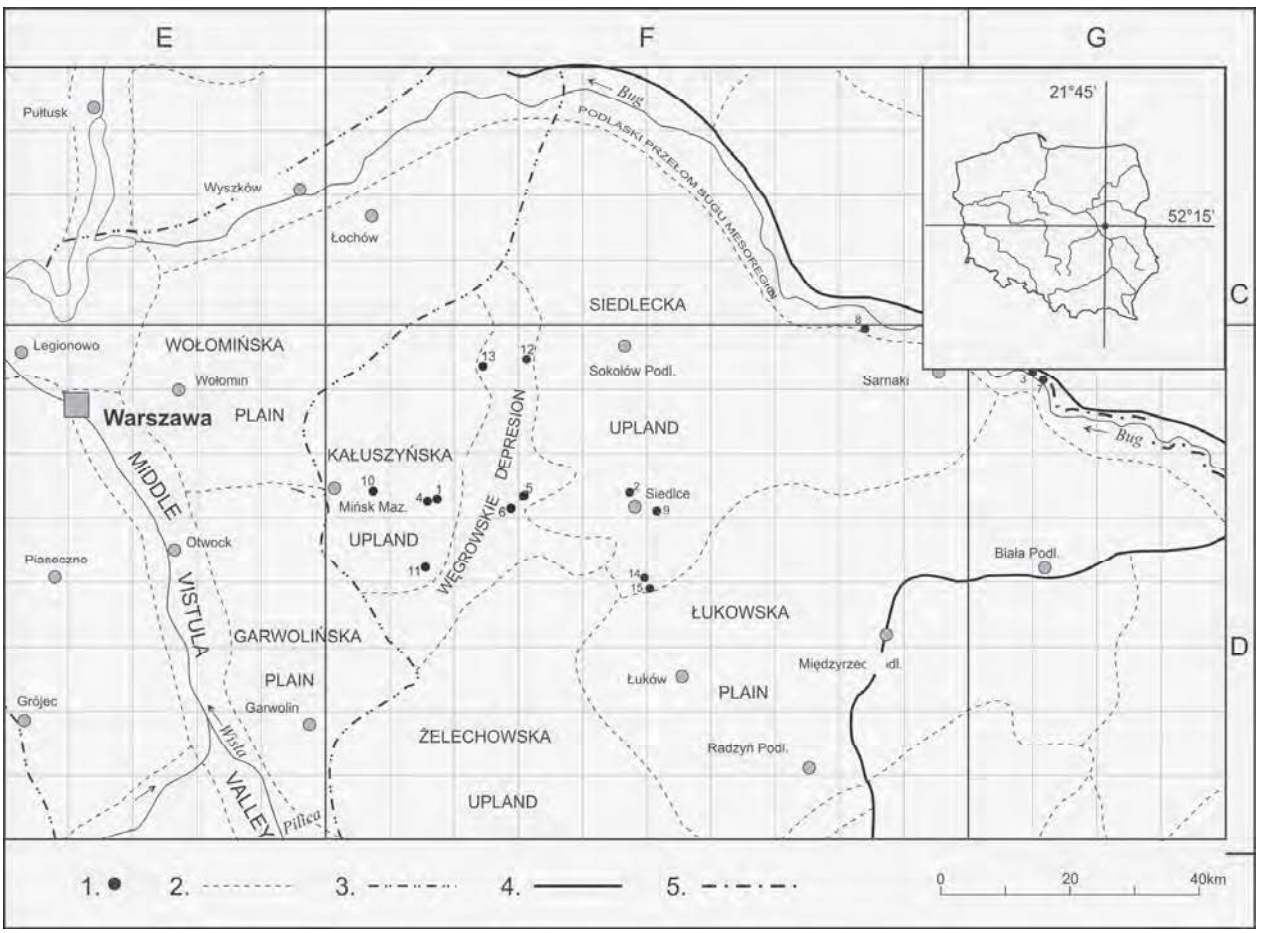


Fig. 1. Location of the study area

Soil quality complexes – 2 – good wheat complex, 4 – very good rye complex, 5 – good rye complex, 6 – weak rye complex, 8 – cereal-fodder strong complex (mainly for wheat), 9 – cereal-fodder weak complex (mainly for rye), A – podzolic soil, B– proper brown soils, Bw – leached and acid brown soils, D – proper meadow black earths, Dz – black degraded earths; pgl – light loamy sand, pgm – heavy loamy sand, pgmp – heavy loamy flour sand, płz – silty loam, żg – clay gravel, gl – light loam, gs – medium loam, gc – heavy loam, "•"– subsoil lies shallow (up to 50 cm)

Table 1.
Geographic location of the *Consolida regalis* sites studied in the Western Podlasie region

| No | Site (local name) | Mesoregions [16] | Coordinates |
|---|---|---|---|
| 1 | Kałuszyn | Kałuszyn Upland | 52 6 46,19N; 21 47 2,95E |
| 2 | Strzała | Siedlce Upland | 52 12 12,53N; 22 15 56,52E |
| 3 | Sutno | PPB | 52 18 38,05N; 23 6 58,23E |
| 4 | Kałuszyn | Kałuszyn Upland | 52 13 16,91N; 21 47 51,11E |
| 5 | Jagodne | Węgrów Depression | 52 12 14,41N; 22 20 36,05E |
| 6 | Bojmie | Węgrów Depression | 52 12 32,06N; 21 57 28,19E |
| 7 | Sutno | PPB | 52 18 13,31N; 23 6 6,48E |
| 8 | Wasilków Skrzeszewski | PPB | 52 25 27,78N; 22 3022,79E |
| 9 | Stok Lacki | Siedlce Upland | 52 9 33,92N; 22 21 49,39E |
| 10 | Jędrzejów | Kałuszyn Upland | 52 12 9,3N; 21 42 56,97E |
| 11 | Piaseczno | Kałuszyn Upland | 52 6 31,2N; 21 44 46,16E |
| 12 | Węgrów | Węgrów Depression | 52 24 2,24N; 21 59 17,23E |
| 13 | Wielądki | Węgrów Depression | 52 23 45,75N; 21 49 42,4E |
| 14 | Kolonia Wiśniew | Siedlce Upland | 52 5 17,59N; 22 17 40,89E |
| 15 | Kolonia Wiśniew | Siedlce Upland | 52 4 44,69N; 22 17 51,94E |

## RESULTS

In the area of Western Podlasie, *Consolida regalis* is not a threatened species. On the contrary, it is a frequent component of segetal flora infesting winter crops and regenerating in uncultivated stubble fields. Royal knight's spur populations grow under a wide range of habitat conditions. (Table 2).

They vary greatly when it comes to generative reproduction and the average seed number per plant ranges from a few tens to over 1200. A high Kruskal-Wallis value ($p \leq 0.05$) of H=320.6, which reflects an association between the characteristic analysed and site, is indicative of high significant differences in seed production potential (Fig. 2).

The analysis of the strength of association between habitat factors and seed production potential revealed significant relationships. The strongest correlation was found between seed production and soil contents of Mg and K; the correlation was slightly weaker between the production and soil pH, soil content of phosphorus and soil unit. No significant relationship was found of seed production with crop plant kind and cover (Table 3).

The highest and most stable seed production was characteristic of the royal knight's spur populations growing on soils of the good wheat complex – sites 13 and 11 in winter triticale and wheat. Crop plant cover was large and reached 85%. The average seed number per plant was 1287 and 965, respectively (Table 4) (Fig. 2).

The respective soil pH was neutral and slightly acidic; soil contents of phosphorus and potassium were high, magnesium content was medium for site 13, whereas for site 11 soil contents of potassium and magnesium were slightly lower (Table 2). Under similar conditions (site 12) but at low K content and 70% cover, the average seed production was highly unstable and half as low – 683 seeds. This population was characterised by the greatest range of seed production potential: from 42 to 3740 seeds per plant. It probably resulted from uneven depletion of soil nutrient reserves in the area of the whole site which was sampled.

The populations growing on soils which were moderately trophically rich had average seed production potential (very good and good rye complex and strong cereal-fodder complex) – sites 2, 3, 7, 8 and 14. (Table 4) (Fig. 2). The soil pH was slightly acidic and soil contents of phosphorus, potassium and magnesium were usually at an average level. The average seed number per plant ranged from 875 and 520.

The poorest generative reproduction was identified for the populations of sites 1, 4, 5 and 15 on poor soils (weak rye complex and cereal-fodder complex). Soil pH ranged from very to slightly acidic and nutrient contents were low, the soil content of magnesium being very low. The average seed number per plant was 83, 42, 155 and 127, respectively. The populations established in stubble and cultivated fields.

Seed production of the sites studied may increase by 20–30% under favourable conditions if the flowers on plants set seeds which survive to maturity.

The analysis of associations between seed production potential and selected morphological characteristics of *Consolida regalis* revealed positive correlations. The strongest association was found between seed production potential and average number of mature follicles, seed production potential and average cluster number as well as seed production potential and average seed number per follicle. By contrast, the relationship of seed production potential with the height to the 1st branching was the weakest. The analysis indicated that morphological characteristics associated mainly with inflorescence structure are the main determinants of seed production potential of plants (Fig. 3).

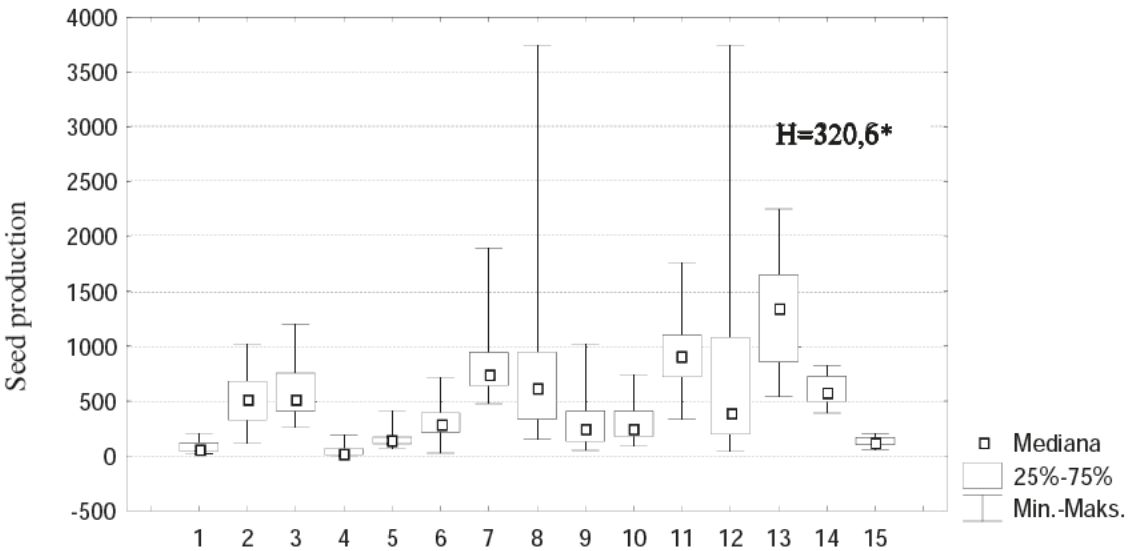


Fig. 2. Variability ranges of seed production potential according to the site. Statistical significance (the Kruskal-Wallis test); * significant at p <0.05

Table 2.
Characteristics of selected sites of *Consolida regalis* Gray growing in the Western Podlasie region

| No | Site | Winter cereals/stubble fields | Cover by cultivated plants (%) | Soil quality complexes | pH | Available forms mg/100g soil | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | KCl | P | K | Mg |
| 1 | Kałuszyn | Stubble fields | – | 6Bw ps | 4.27 | 14.7 | 7.5 | 1.5 |
| 2 | Strzała | Stubble fields | – | 4 Dzgl:ps | 5.22 | 11.3 | 12.1 | 7.4 |
| 3 | Sutno | Stubble fields | – | 5A pgl:gl | 5.84 | 21.4 | 15.7 | 7.7 |
| 4 | Kałuszyn | Secale cereale | 50 | 6Bw żpl | 6.38 | 17.7 | 7.0 | 3.1 |
| 5 | Jagodne | Secale cereale | 50 | 6Bw pgl.pl | 6.14 | 8.6 | 5.0 | 2.1 |
| 6 | Bojmie | Triticale | 70 | 5 A pgl:gl | 5.74 | 22.2 | 15.0 | 3.7 |
| 7 | Sutno | Triticale | 75 | 5A pgl:gl | 6.4 | 19.4 | 17.2 | 3.9 |
| 8 | Wasilew Skrzeszewski | Triticale | 75 | 4Bw pgm.gl | 6.3 | 20.4 | 16.2 | 6.5 |
| 9 | Stok Lacki | Triticale | 75 | 4Agl | 5.1 | 9.3 | 11.0 | 3.4 |
| 10 | Jędrzejów | Triticale | 80 | 4Apgm.gs | 5.5 | 8.9 | 12.1 | 3.8 |
| 11 | Piaseczno | Triticum vulgare | 85 | 2Apgm.gc | 6.16 | 36.0 | 30.5 | 9.1 |
| 12 | Węgrów | Triticale | 70 | 2D gs | 6.5 | 15.4 | 12.5 | 8.1 |
| 13 | Wielądki | Triticale | 85 | 2Bw pgmp.gs | 6.7 | 34.2 | 31.1 | 9.7 |
| 14 | Kolonia Wiśniew | Triticum vulgare | 45 | 8Bw pgmp.gl | 6.11 | 30.0 | 30.5 | 7.5 |
| 15 | Kolonia Wiśniew | Triticum vulgare | 75 | 9Dzpgm.gl | 4.52 | 11.9 | 11.5 | 2.9 |

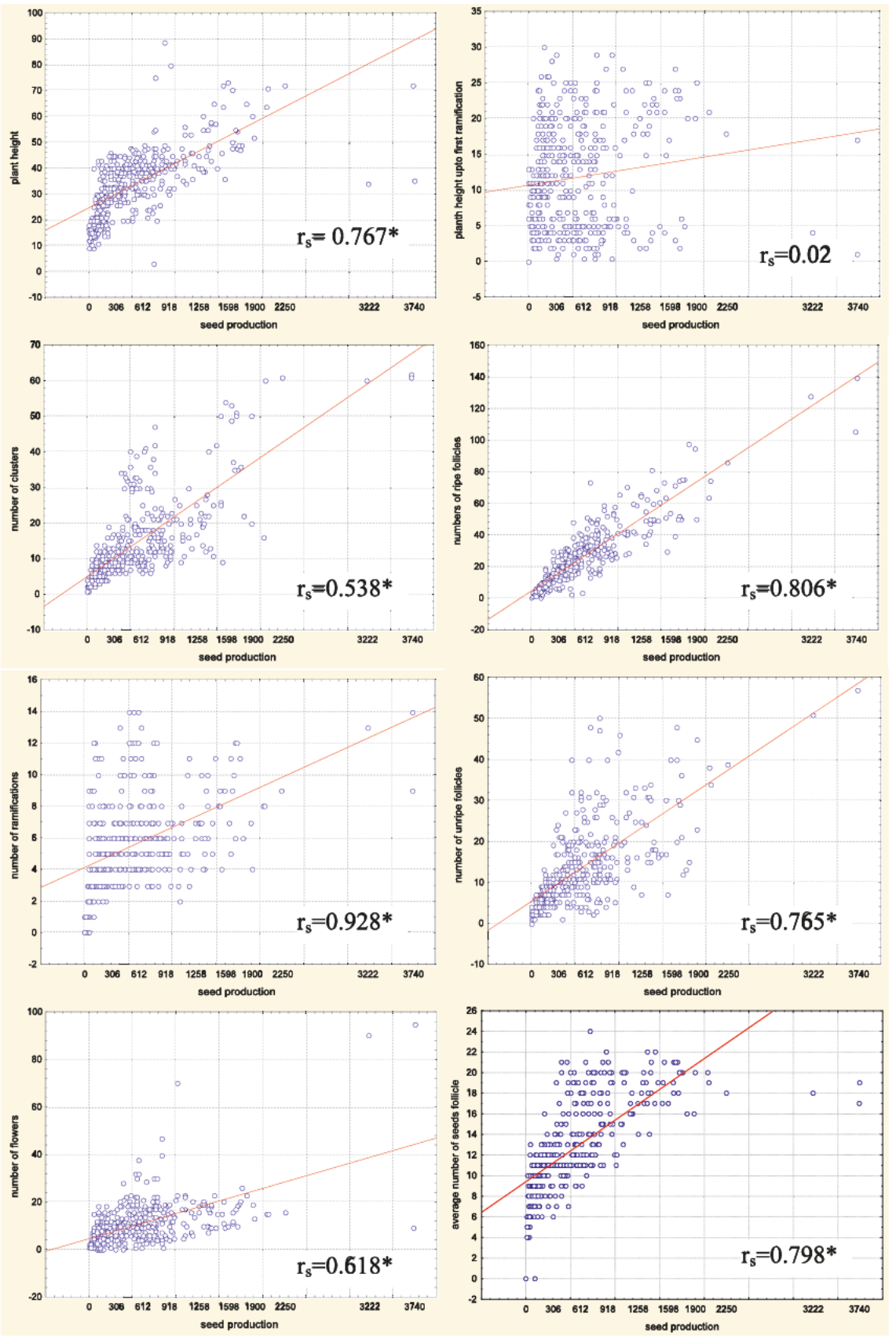


Fig 3. Association between *Consolida redalis* seed production potential and selected morphological characteristics as indicated by the Spearman's correlation of rank order at $p<0.05$.

Table 3
Spearman's rank-order coefficients between seed production potential and selected habitat characteristics

| Pair of variables | Spearman's rank-order correlation at p<0.05 |
|---|---|
| Soil & seed production potential | 0.757893* |
| Cultivation & seed production potential | 0.011194 |
| % of crop plant cover & seed production potential | 0.480611 |
| soil pH & seed production potential | 0.617857* |
| P & seed production potential | 0.632143* |
| K & seed production potential | 0.889089* |
| Mg & seed production potential | 0.867857* |

*significant at<0.05

Table 4
Average seed production of *Consolida regalis* Gray at the sites studied

| No | Site | Average number of seeds per plant | Variation coefficient % |
|---|---|---|---|
| 1 | Kałuszyn | 83 | 69 |
| 2 | Strzała | 520 | 47 |
| 3 | Sutno | 590 | 41 |
| 4 | Kałuszyn | 42 | 114 |
| 5 | Jagodne | 155 | 47 |
| 6 | Bojmie | 314 | 51 |
| 7 | Sutno | 875 | 44 |
| 8 | Wasilew Skrzeszewski | 843 | 97 |
| 9 | Stok Lacki | 330 | 73 |
| 10 | Jędrzejów | 310 | 55 |
| 11 | Piaseczno | 965 | 41 |
| 12 | Węgrów | 683 | 112 |
| 13 | Wielądki | 1287 | 35 |
| 14 | Kolonia Wiśniew | 598 | 21 |
| 15 | Kolonia Wiśniew | 127 | 32 |

## DISCUSSION

*Consolida regalis* is a weed typical of winter cereals. It is classified as an indicator of dense soils which are rich in calcium carbonate. The plant's light requirements are high and it prefers warm sites [9,10]. The royal knight's spur occurred in a range of habitats in the study area, which indicates that the plant is tolerant of unfavourable soil conditions. *Consolida regalis* was found on both dense soils with high pH values and light trophically poor and acid soils. However, the species clearly prefers fertile soils and then its seed production potential is the highest. Many authors [1,3,11] have reported that dense cereal stands are the factor which limits the development and seed production potential of many weed species. The present study has demonstrated that the above finding is not true for the royal knight's spur, the species which has evolutionarily adjusted to the cereal development cycle. In dense stands plants were found which were much taller than the typical plants reported in literature [12,13]. Moreover, they had more branches in the topmost part of the canopy which receives most sunlight [14]. Populations in these sites produced the greatest number of seeds of all the samples subjected to analysis. Substantial differences in population generative

reproduction which are apparently observed under the same habitat conditions (large plant cover, good wheat complex) depended on soil contents of P, K and Mg as well as soil pH. Decreasing nutrient contents were associated with lower *Consolida regalis* seed production which dropped by 25% in site 11 and by as much as 53% in site 12. Even on light soils *Consolida regalis* seed production was quite high when the soils had optimum nutrient contents. Also Podstawka-Chmielewska et al. [3] and Kwiecińska-Poppe [2] pointed out to habitat conditions as the main factors affecting seed production levels of some weeds infesting various crops.

The analyses of statistical correlations confirmed that the seed production potential of the populations studied was very much influenced by soil contents of P, K and Mg as well as by soil pH. In contrast, crop plant cover and kind were not significant. The morphological characteristics which significantly affected seed production potential included plant height and traits associated with inflorescence structure. The association between seed production potential and plant height were reported by authors such as Majda et al. [5] for fallow species as well as Rzymowska and Skrzyczyńska [15] for *Agrostemma githago* and *Centaurea cyanus* in the Siedlce Upland region.

## CONCLUSIONS

1. *Consolida regalis* is highly variable in terms of seed production potential, which is influenced by habitat conditions.
2. Seed production potential is most strongly correlated with soil contents of Mg, K, and P as well as with soil pH, whereas crop plant kind and cover are insignificant.
3. Morphological characteristics which are most strongly correlated with seed production potential include the following: number of mature and immature follicles, number of seeds per follicle, number of clusters, and plant height.

### Acknowledgements

Research supported by the Ministry of Science and Higher Education of Poland as part of the statutory activities of the Department of Agricultural Ecology, Siedlce University of Natural Sciences and Humanities.

### Authors' contributions

The following declarations about authors' contributions to the research have been made: concept of the study: TS, MŁ; field work: TS, MŁ; data analyses: TS, MŁ; writing of the manuscript: TS, MŁ, JS.

## REFERENCES

1. Kwiecińska-Poppe E. Plenność niektórych gatunków chwastów segetalnych na glebie lekkiej. Ann UMCS Sec E. 2004; 59(3): 1183–1191.
2. Kwiecińska-Poppe E. Plenność wybranych gatunków chwastów segetalnych na ciężkiej rędzinie czarnoziemnej. Acta Agrophys. 2006; 8(2): 441–448.
3. Podstawka-Chmielewska E, Kwiatkowska J, Kosior M. Plenność niektórych gatunków chwastów segetalnych w łanie różnych roślin uprawnych na glebie lekkiej i ciężkiej. Ann UMCS Sec E. 2000; 55(4): 29–39.
4. Jędruszczak M. Reprodukcja generatywna chwastów na ścierniskach po życie ozimym. Ann UMCS Sec E. 2000; 55(2): 67–76.
5. Majda J, Buczek J, Trąba C. Plenność niektórych chwastów występujących na odłogu. Ann UMCS Sec E. 2007; 62(2): 48–55.
6. Bomanowska A. Threat to arable weeds in Poland in the light of national and regional red lists. Plant Breed Seed Sci. 2010; 61: 55–74. http://dx.doi.org/10.2478/v10129-010-0013-7
7. Pender K, Szczeniak E. *Consolida regalis* (Ranunculaceae) na Dolnym Śląsku – gatunek na progu zagrożenia. Acta Bot Siles. 2011; 1: 108–110.
8. Sobczyk M. Statystyka. Warsaw: Polish Scientific Publishers PWN; 2007.
9. Ellenberg H, Weber H, Dull R, Wirth V, Werner W, Paulissen D. Zeigerverte von Pflanzen in Mitteleuropa. Scr. Geobot. 1992; 18: 1–97.
10. Zarzycki K, Trzcińska-Tacik H, Różański W, Szeląg Z, Wołek J, Korzeniak U. Ecological indicator values of vascular plants of Poland. Cracow: W. Szafer Institute of Botany, Polish Academy of Sciences; 2002.
11. Skrzyczyńska J, Ługowska M, Skrajna T. Wybrane cechy morfologiczne *Polygonum lapathifolium* subsp. *lapathifolium* w zależności od gatunku rośliny uprawnej. Pam Puł. 2009; 150: 265–272.
12. Mowszowicz J. Krajowe chwasty polne i ogrodowe. Przewodnik do oznaczania. Warsaw: Powszechne Wydawnictwo Rolnicze i Leśne; 1986.
13. Rutkowski L. Klucz do oznaczania roślin naczyniowych Polski niżowej. Warsaw: Polish Scientific Publishers PWN; 2007.
14. Skrajna T, Skrzyczyńska J, Ługowska M. Zróżnicowanie wybranych cech morfologicznych i biologicznych *Consolida regalis* Gray na terenie Podlasia Zachodniego. Ekol Tech. 2011; 19(3A): 14–150.
15. Rzymowska Z, Skrzyczyńska J. Niektóre cechy biologiczne *Agrostemma githago* L. i *Centaurea cyanus* L. w różnych siedliskach Wysoczyzny Siedleckiej. Ann UMCS Sec E. 2007; 62(2): 82–89.
16. Kondracki J. Geografia regionalna Polski. Warsaw: Polish Scientific Publishers PWN; 2002.

## Wpływ uprawy pasowej i metod regulacji zachwaszczenia na różnorodność chwastów w kukurydzy pastewnej (*Zea mays* L.), owsie siewnym (*Avena sativa* L.) i łubinie wąskolistnym (*Lupinus angustifolius* L.)


### Streszczenie

Doświadczenie przeprowadzono w latach 2008–2010 w Stacji Doświadczalnej Wydziału Nauk Rolniczych, Uniwersytetu Przyrodniczego w Lublinie. Schemat badań obejmował dwa czynniki: I. Metoda uprawy – siew czysty i uprawa pasowa, polegająca na uprawie w sąsiadujących ze sobą pasach o szerokości 3,3 m trzech roślin: kukurydzy pastewnej, łubinu wąskolistnego i owsa siewnego; II. Metoda regulacji zachwaszczenia – mechaniczna i chemiczna Przedmiotem badań było zachwaszczenie kukurydzy pastewnej odmiany 'Celio', łubinu wąskolistnego odmiany „Sonet" i owsa siewnego odmiany 'Kasztan'. Zachwaszczenie roślin określano dwa tygodnie przed zbiorem, metodą botaniczno-wagową, określając skład florystyczny i liczebność poszczególnych gatunków chwastów oraz ich powietrznie suchą masę.

Największą różnorodność chwastów stwierdzono z zasiewach łubinu wąskolistnego, najmniejszą zaś w kukurydzy pastewnej. Gatunkami dominującymi w zachwaszczeniu kukurydzy, łubinu wąskolistnego i owsa siewnego były *Echinochloa crus-galli*, *Chenopodium album* oraz *Galinsoga parviflora* stanowiące od 34,1% do 99% ogólnej liczby chwastów. Uprawa pasowa wyraźnie zmniejszała liczbę chwastów na jednostce powierzchni w zasiewach łubinu wąskolistnego i owsa siewnego oraz wytworzoną przez nie sucha masę części nadziemnych we wszystkich uprawianych gatunkach. Chemiczna metoda regulacji zachwaszczenia zmniejszała istotnie zarówno liczbę jak i masę chwastów w porównaniu z metodą mechaniczną.


Handling Editor: Elżbieta Pogroszewska