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INFLUENCE OF THE WEATHER CONDITIONS ON FABA BEAN YIELDING

WPŁYW WARUNKÓW POGODOWYCH NA PLONOWANIE BOBIKU

Abstract: The aim of this work was to determine the relationship between faba bean seeds yield, number of its seeds per sqm (m^2) as well as 1000 seeds weight and meteorological factors and their deviations from optimal values. Results of experinients conducted in 1989–1991, 1993–1995 and 1999–2003 at the Experimental Station Prusy near Krakow were shown in this paper. The yield of faba bean grown on degraded chernozem, ranged between 2.11 and 5.20 Mg · ha^{-1}. The seed yield demonstrated high correlation with the number of seeds per sqm, and much lower with weight of 1000 seeds. There were no statistical significant correlation between yield of seeds and meteorological factors. Weight of 1000 seeds have been positively correlated with deviation of precipitation sum from water requirements in the period April–August, and with average air temperature in April. Number of seeds per sqm was significant correlated with deviation of precipitation sum from water requirements in may and average air temperature in April.

Keywords: faba bean, yield, rainfall, temperature, Sielianinov coefficient

Crop yielding depends mainly on the weather course, soil conditions and properly applied agrotechnological measures. Direct unfavourable effect of the weather conditions (such as hail, drought or high temperatures) leads to the occurrence of abiotic stress in plants, which is the cause of low stability of the legume yielding. Moreover they directly influence the features determining the amount of seed yield, ie the plant density, the number of pods per plant, the number of seeds per pod and 1000 seed weight. Faba bean water requirements during the growing period are estimated for between 300–500 mm [1–3] depending on the soil kind. Both deficiency and excess of rainfall negatively affect the amount of seed yield and the yield structure elements [2, 4,

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5]. Faba bean thermal requirements are described as moderate [2]. Low temperatures during the initial period of development favour vernalization and positively influence the development of the root system. Too low temperatures during shooting accompanied by heavy rainfall may be reason of cool-water stress adversely affecting further plant development [6]. High temperature at the ripening time contributes to shortening of this stage, which is unfavourably reflected in the quantity of seed yield. According to Michalska [2] the air amplitudes not exceeding 10 ^{o}C are optimal for faba bean yielding. The effect of the weather conditions, beside the basis agrotechnological factors, is the main source of low stability of faba bean yielding [5, 7, 8–10]. Variability of seed yield caused by the effect of weather conditions may reach between 20 and 40 %.

The research aimed to determine the relationship between the amount of seeds yield, 1000 seed weight and seed number per 1 m^2 of faba bean and the weather conditions, such as the air temperature, rainfall amount, hydrothermal coefficient and rainfall total deviation from faba bean rainfall requirements.

Material and methods

Presented work has used the results obtained in the field experiments conducted in the years 1989–1991, 1993–1995 and 1999–2003 at the experimental Station in Prusy near Krakow. The experiments were localized on degraded chernozem of very good wheat complex and first class quality soil. Meteorological data supplied by the automatic Hardi Metpole meteorological station comprising the air temperature and rainfall amount were used for the statistical analyses conducted. On the basis of these measurements the value of Silianinov hydrothermal coefficient was computed and deviations from rainfall needs of faba bean cultivated under conditions of heavy soil [3]. The relationship between the analyzed variables was determined using linear correlation analysis. The empirical model for estimating 1000 seed weight was determined on the basis of stepwise regression.

Results

The pattern of weather conditions during faba bean vegetation (April–August) over the multiannual period 1961–1990 and in the analogous months during the investigations conducted in 1989–2005 was greatly diversified (Table 1). Average air temperature during the period from April to August was 14.3 ^{o}C and was by 0.9 ^{o}C higher than the multiannual mean, which points to apparent climate warming in the last decade of the 20th century and in the first years of the present century. July and August were particularly warm months. Precipitation total during faba bean vegetation in 1989–2005 was lower by an average of 49 mm than the precipitation total of the analogous period in the years 1961–1990 however, smaller amount of rainfall occurred from May till August.

Table 1

Characteristic of meteorological conditions in the Experimental Station Prusy

Months	Mean		Minimum	Maximum	Standard deviation	CV %
	1961–1990	1989–2005				
Mean air temperature						
IV	7.9	8.6	6.9	11.8	1.3	14.6
V	13.1	13.8	10.8	16.3	1.6	11.8
VI	16.2	16.3	14.7	17.8	0.9	5.5
VII	17.5	18.8	16.4	21.8	1.6	8.6
VIII	16.9	18.4	16.7	19.8	0.9	5.0
IV–VIII	14.3	15.2	14.2	16.1	0.6	4.2
Sum of precipitation						
IV	48.0	60.7	19.8	145.7	36.9	60.8
V	83.0	69.6	27.3	136.4	28.2	40.5
VI	97.0	81.9	32.9	201.0	48.8	59.6
VII	85.0	74.0	30.6	212.7	50.7	68.5
VIII	87.0	64.9	16.2	122.2	31.7	48.8
IV–VIII	400.0	351.1	213.3	522.4	78.0	22.2
Sielianinow coefficient						
IV	2.0	2.4	0.8	5.9	1.5	61.9
V	2.0	1.7	0.7	3.1	0.7	45.0
VI	2.0	1.7	0.7	3.9	1.0	59.6
VII	1.6	1.3	0.5	4.1	1.0	74.5
VIII	1.7	1.1	0.3	2.2	0.6	51.1
IV–VIII	1.8	1.5	0.9	2.2	0.3	21.6

Excess or deficiency of rainfall in the individual months of vegetation and aggregate amounts over the April–August period were shown in Fig. 1. Analysis of this graph shows that the greatest amount of evenly distributed rainfall occurred in 2001, which was connected with maximum seed yield – 5.20 Mg · ha^{-1}. In the other years periods of deficient or excessive rainfall occurred too but their pattern was uneven, which resulted in much lower seed yields. In the discussed region the most unfavourable for faba bean yielding were the years of 1989, 1990, 1994 and 2000 when the produced yields were much below the average – 3.95 Mg · ha^{-1} whereas the lowest – 2.11 Mg · ha^{-1} was obtained in 1990 (Fig. 2).

Due to negative correlations between plant density and the numbers of pods and seeds per plant, the detailed analysis of the weather factors effect on individual yield structure elements was abandoned and replaced by a synthetic indicator, ie the number

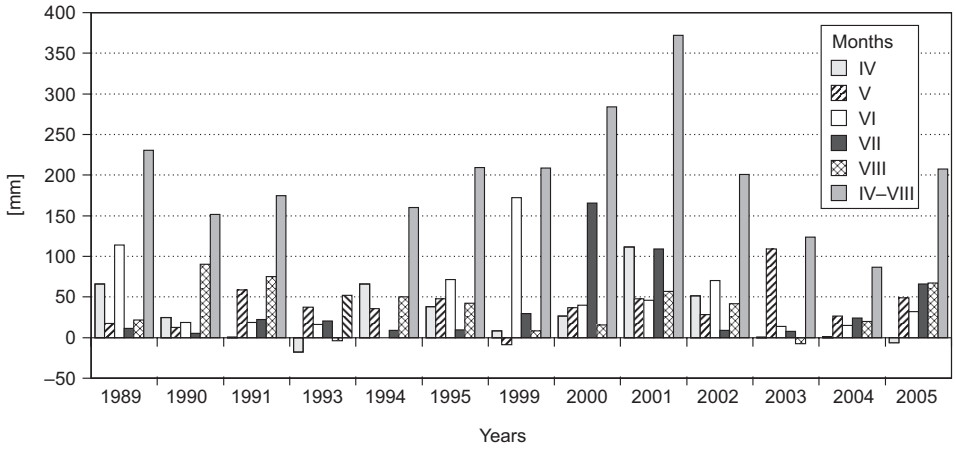

Fig 1. Excess and deficit of precipitation in relationship to faba bean rainfall requirements

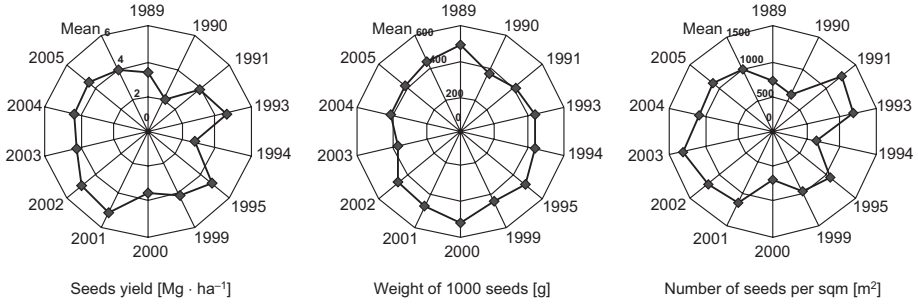

Fig 2. Yield of seeds, weight of 1000 seeds and number of seds per sqm in the respective yers of study

of seeds per 1 m^2 of the plantation area. As demonstrated by Nachi and Guen [11] in 15 analyzed genotypes this feature was significantly correlated with seed yield (r = 0.85). Low seed yield in 1990 was the consequence of both small number of seeds per 1 m^2 and 1000 seed weight. As has been demonstrated by the results for the whole period of investigations, the number of seeds per 1 m^2 is significantly positively correlated with the amount of faba bean seed yield (Table 2). Faba bean plant development was unfavourably influenced in 1990 by a considerable amount of rainfall in August, however no significant correlation was found between the values of meteorological factors in the individual months and the seed yield. 1000 seed weight revealed the highest correlation with the deviations of rainfall total from rainfall requirements in the April–August period and average monthly temperature in April, whereas the number of seeds per m^2 with rainfall total deviations from rainfall requirements in May and average monthly temperature in April (Table 1). 1000 seeds weight was to a greater degree correlated with the values of Sielianinov hydrothermal coefficient than the number of seeds per 1 m^2.

Table 2

Simple correlation coefficients between investigated traits

Months	Seeds yield	Weigth of 1000 seeds	Number of seeds per sqm (x_1)
Weigth of 1000 seeds	0.28	—	
Number of seeds per sqm (x_1)	0.83***	–0.14	—
Mean air temperature			
IV	–0.22	0.59**	–0.54*
V	0.26	0.35	0.11
VI	0.08	–0.16	0.30
VII	0.24	0.08	0.27
VIII	0.24	0.30	0.23
IV–VIII	0.26	0.49*	0.14
Sum of precipitation			
IV	0.06	0.44	–0.15
V	0.20	–0.38	0.46*
VI	0.15	0.44	–0.07
VII	0.11	0.49*	–0.23
VIII	–0.34	–0.29	–0.22
IV–VIII	0.13	0.54*	–0.19
Sielianinow coefficient			
IV	0.12	0.34	–0.04
V	0.12	–0.43	0.43
VI	0.13	0.46	–0.11
VII	0.04	0.48*	–0.28
VIII	–0.36	–0.33	–0.23
V–VIII	0.06	0.46	–0.22
Excess and deficit of precipitation			
IV	0.03	0.54	–0.31
V	0.28	–0.29	0.56*
VI	0.16	0.43	–0.10
VII	0.15	0.52	–0.16
VIII	–0.32	–0.25	–0.23
V–VIII	0.17	0.61**	–0.18

Using stepwise regression a multiple regression equation first class quality soil was set up for estimating 1000 seed weight of faba bean, Nadwislanski c.v. for the analyzed period at the Experimental Station in Prusy, which assumed the following form. Introduction of new variables to the model from x_1 to x_2 increased the determination coefficient from 0.37 to 0.69.

$$Y = 447.8 + 0.658\ x_1 - 0.478\ x_2 - 0.339\ x_3;$$
$$F(3.9) = 6.6592;\ p < 0.0116;\ R^2 = 0.69$$

where: Y – weight of 1000 seeds,
x_1 – total deviation of rainfall from the rainfall requirements in the period April–August,
x_2 – Sielianinow coefficient in August,
x_3 – sum of precipitation in May.

Conclusions

1. Over the13-year period of experiments on degraded chernozem the seeds yield of faba bean Nadwislanski cv. ranged from 2.11 to 5.20 Mg · ha^{-1}. It was significantly positively correlated with the number of seeds per 1 m^2.

2. 1000 seeds weight revealed the highest correlation with the rainfall total deviations from the water requirements during the April–August period and average monthly temperature in April, whereas the number of seeds per 1 m^2 with the deviations of rainfall total from rainfall needs in May and average monthly temperature in April. No significant correlation was found between the values of meteorological factors in the individual months and seed yield.

3. Using stepwise regression a multiple regression equation was set up for estimating 1000 seeds weight on the basis of the following variables: a total of rainfall deviations from rainfall requirements in the April–August period, value of Sielianinov coefficient in August and rainfall total in May.

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WPŁYW WARUNKÓW POGODOWYCH NA PLONOWANIE BOBIKU

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Abstrakt: Celem pracy było określenie zależności pomiędzy plonem nasion, liczbą nasion na m^2 oraz masą 1000 nasion bobiku (Nadwiślański) uprawianego na czarnoziemie zdegradowanym a czynnikami pogodowy-

mi (średnią miesięczną temperaturą powietrza, miesięczną sumą opadów, współczynnikiem hydrotermicznym oraz odchyleniami sumy opadów od potrzeb opadowych bobiku). W pracy wykorzystano wyniki badań polowych przeprowadzonych w Stacji Doświadczalnej w Prusach (Uniwersytet Rolniczy w Krakowie) w latach 1989–1991, 1993–1995 i 1999–2003. Bobik plonował w granicach 2,11–5,20 Mg · ha^{-1}. Plon nasion wykazywał wysoką istotną korelację z liczbą nasion na 1 m^2, a znacznie mniejszą i nieistotną z masą 1000 nasion. Nie stwierdzono istotnej korelacji pomiędzy wielkościami czynników meteorologicznych w poszczególnych miesiącach a plonem nasion. Masa 1000 nasion wykazywała największą korelację z odchyleniami sumy opadów od potrzeb opadowych w okresie kwiecień–sierpień oraz średnią miesięczną temperaturą kwietnia, natomiast liczba nasion na m^2 z odchyleniami sumy opadów od potrzeb opadowych w maju oraz średnią miesięczną temperaturą kwietnia

Słowa kluczowe: bobik, opady, temperatura, współczynnik Sielianinowa