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Effect of mineral fertilization on yielding of spring false flax and crambe

Wpływ nawożenia na plonowanie lnianki jarej i katranu abisyńskiego

Słowa kluczowe: katran, lnianka, azot, siarka, magnez
Key words: false flax, crambe, nitrogen, sulphur, magnesium, fertilization

W pracy porównywano wpływ nawożenia przedsiewnego NPK (125 kg ha^{-1}) + S (25 kg ha^{-1}) lub Mg (5 kg ha^{-1}) oraz pogłównego N (0, 20, 35+5, 40) na pokrój roślin, elementy struktury plonu i plon obu gatunków. Siarka w dawce 25 kg oraz magnez w dawce 5 kg stosowane przedsiewnie razem z NPK (125 kg) nie różnicowały istotnie plonu nasion lnianki jarej i owocków katranu abisyńskiego. Lnianka jara plonowała najwyżej (21,4 dt z ha) na obiektach nawożonych dawką przedsiewną i pogłówną (w równych częściach) 80 kg azotu. Zamiana części azotu z formy stałej na roztwór wodny nie różnicowała istotnie wysokości plonu. Najkorzystniejszym sposobem nawożenia katranu abisyńskiego azotem było zastosowanie połowy dawki (40 kg) przedsiewnie, a drugiej połowy pogłównie w formie stałej (35 kg) oraz w roztworze (5 kg).

In the paper the effects of fertilization on yield and its components of two studied species are compared. The following treatments were taken into consideration: pre-sowing NPK (125 kg ha^{-1}) + S (25 kg ha^{-1}) or + Mg (5 kg ha^{-1}) and top dressing with nitrogen (0, 20, 35+5, 40 kg N ha^{-1}). It was found that sulphur and magnesium application together with NPK did not affect yield of false flax and crambe. The highest yield of false flax (2.14 tons ha^{-1}) was noted for treatment with split nitrogen rate of 80 kg. The method of nitrogen application (as solid urea or in solution) did not affect crop yield. The best yield of crambe was obtained when 50% of the total nitrogen rate (40 kg ha^{-1}) was given before sowing and the second half as 35 kg in solid urea + 5 kg as urea solution.

Introduction

In Polish climatic conditions, of all oil crops only species of Brassiceae family are most frequently grown. Recently, however, home oil industry has not been interested in buying oil crops other than rapeseed. Other oil crops may be used also for other purposes than food production.

False flax seeds can be used as a source of fast drying oil rich in linoleic and linolic acids. This oil can be raw material to produce varnish, paints and special kind of soap. Yield of spring form ranges from, 0.7 to 1.34 tons ha^{-1} and oil content in seeds ranges from 25 to 46 per cent. (Budzyński, Jankowski 1999; Dembiński 1975, Dembiński et al. 1962; Muśnicki et al. 1997). There are no new reports about growing of this crop.

Crambe oil is high in erucic acids, therefore it might be applied only for technological purposes. The important advantage of this species is its tolerance to soil pollution with heavy metals showing no increase of these metals in generative organs. (Kulig et al. 1998). Crambe shows high variability of seed yields from 1.2 to 3.5 dt ha^{-1} (Dembiński et al. 1962, Kulig 1997, Muśnicki et al. 1997). The last report deals with response of this crop to nitrogen fertilization (Kulig 1997).

The aim of the presented studies was to determine the effects of different methods of fertilization of yield and yield components of crambe and false flax.

Methods

Field experiment with false flax and crambe was performed at the Experimental Station in Bałcyny during seasons 1997–1999. Design of balanced subplots with three replications was applied and the experimental factors were as follows:

First order factor — method of pre-sowing ferilization:

1. N – 40, P_2O_5 – 30, K_2O – 55, S – 25 (kg ha^{-1}),
2. N – 40, P_2O_5 – 30, K_2O – 55, Mg – 5 (kg ha^{-1}).

Sulphur was applied in complete fertilizer Hydro „S", magnesium in fertilizer Hydro Viking „Mg" and rates of nitrogen were balanced with ammonium nitrate.

Second order experimental factor – level and method of nitrogen top dressing:

a. control – without nitrogen;
b. 20 kg·N ha^{-1} (solid urea);
c. 35 kg·N ha^{-1} (solid urea) + 5 kg N ha^{-1} (urea in 6% water solution);
d. 40 kg N ha^{-1} (solid urea).

Top dressing with solid urea was applied at the stage of the beginning of blooming and spraying with 6% urea was applied at the phase of full blooming.

Experiment was performed on typical Luvisol originated from medium loam classified to good wheat complex, according to Polish Soil Science Society. The following amounts of macro-nutrients were recorded: 13.6–14.2 mg P_2O_5, 15.0–15.6 mg K_2O, 7.6–9.7 mg Mg, 0.61 mg S-SO_4 · 100 g^{-1} of the soil and total sulphur level 0.07% S. Soil pH in KCl ranged from 6.2 to 6.6. Forecrop was winter wheat. After wheat harvesting standard after harvest practices were applied and then winter ploughing. Crop sowing was carried at the end of April using 300 germinating spores per 1 m^2 of false flax and 100 crambe, respectively. Sowing was performed on plots of the area of 7.5 m^2 in row spacing of 20 cm. False flax was harvested by two stage methods of harvesting at the end of July (1999) or in the first days of August (1997 and 1998); crambe at the end of July (1999) or in middle August (1997 and 1998).

Results

Pattern of weather conditions

In season 1997 weather was favourable for growth and development of spring oil corps. Daily temperature only in April and August was different from mean of many years (Table 1). Precipitation level during seed emergence, blooming and start of flowering of studied crops (May – June) was close to the value of many years mean. At the stage of full flowering and seed maturation 2.56 higher level of precipitation was recorded comparing to many years mean value.

In 1998 mean daily temperature level during growing period of false flax and crambe was close to pattern recorded in period 1960–1990. Precipitation before sowing and at the stage of seed emergence was at level typical of many years. During blooming and flowering high level of precipitation was noted (twice as high as in compared many years period). Therefore false flax and crambe plants were weak, number of branches was low and yield level was generally low.

Table 1

Pattern of weather conditions in growing periods in 1997–1999
Warunki pogodowe w okresie wegetacji w latach 1997–1999

Season of the studies *Okres badań*	Months — *Miesiąc*					
	March *marzec*	April *kwiecień*	May *maj*	June *czerwiec*	July *lipiec*	August *sierpień*
Daily mean temperature — *Średnia temperatura dnia* [°C]						
1997	2.1	4.0	11.4	15.7	16.9	18.3
1998	0.4	9.0	13.3	16.2	16.3	15.2
1999	3.7	8.3	11.0	16.7	19.2	16.9
Many years 1961–90 *Średnie roczne 1961–90*	1.2	6.6	12.4	15.7	16.9	16.5
Precipitation — *Opady* [mm]						
1997	31.2	22.6	99.0	71.7	187.6	25.1
1998	38.1	44.5	58.3	141.9	57.5	58.3
1999	18.4	101.6	69.1	155.6	75.5	53.0
Many years 1961–90 *Średnie roczne 1961–90*	27.4	35.2	56.7	68.3	81.3	78.1

In 1999 pattern of temperature was favourable for growth of spring oil crops. Daily temperature in July was slightly different from many years value (Table 1). Before sowing and during generative phases of crops growth precipitation level was twice higher comparing to values of many years.

False flax

First experimental factor (level of NPK ferilization and S and Mg application) did not affect morphological features of false flax plants. Top dressing resulted in increase of plant height (average by 3 cm) and more fruit-bearing branches were recorded. Nitrogen rate (20 or 40 kg N ha^{-1}) did not differentiate values of morphological features.

Table 2

Morphological features of spring false flax plants — *Cechy morfologiczne roślin lnianki*

Before sowing fertilization *Nawożenie przedsiewne*	Nitrogen top dressing — *Nawożenie pogłówne azotem* [kg ha^{-1}]				Mean *Średnia*
	0	20 (solid fertilizer[1]) *(nawóz stały[1])*	35 (solid fertilizer[1]) *(nawóz stały[1])* + 5 (solution[2]) *(roztwór[2])*	40 (solid fertilizer[1]) *(nawóz stały[1])*	
Plant height before harvesting — *Wysokość roślin przed zbiorem* [cm]					
NPK + S	76	80	82	79	79
NPK + Mg	77	78	78	80	78
Mean — *Średnia*	76	79	80	80	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – 2 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 2*					
Stem base diameter — *Średnia podstawy łodygi* [cm]					
NPK + S	3.3	3.5	3.6	3.7	3.5
NPK + Mg	3.5	3.7	3.7	3.7	3.7
Mean — *Średnia*	3.4	3.6	3.7	3.7	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Number of fruits bearing branches per plant — *Liczba odgałęzień owoconośnych na roślinie*					
NPK + S	3.1	3.6	4.0	4.1	3.7
NPK + Mg	3.0	3.4	4.0	3.9	3.6
Mean — *Średnia*	3.0	3.6	4.0	4.0	
LSD (α = 0,05): before sowing fertilization – n. s.; nitrogen top dressing – 0.5 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 0.5*					
Stand deflection — *Pochylenie łanu*					
NPK + S	20	31	34	41	32
NPK + Mg	22	32	31	34	30
Mean — *Średnia*	21	31	33	38	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – 5 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 5*					

[1] — urea at the beginning of blooming — *mocznik na początku kwitnienia*
[2] — 6% urea solution at full of blooming — *6% roztwór mocznika w pełni kwitnienia*
n. s. — not significant *r. n. — różnice nieistotne*

Every year intensive lodging of false flax stand was observed and it was related to the level of nitrogen applied as top dressing. The lowest level of lodging was noted on the plots where top dressing was not applied (21% of stand deflection). Rate of 20 kg N ha^{-1} increased this value by 10%. Application of the rate of 40 kg N ha^{-1} resulted in more intense stand deflection but it was not so visible when this rate was split as solid urea and water solution (Table 2).

Values of yield components of false flax were not related to the method of pre-sowing ferilization.

Table 3

Yield components of false flax plants — *Składniki plonu lnianki*

Before sowing fertilization *Nawożenie przedsiewne*	Nitrogen top dressing — *Nawożenie pogłówne azotem* [kg ha^{-1}]				Mean *Średnia*
	0	20 (solid fertilizer[1]) *(nawóz stały[1])*	35 (solid fertilizer[1]) *(nawóz stały[1])* + 5 (solution[2]) *(roztwór[2])*	40 (solid fertilizer[1]) *(nawóz stały[1])*	
Plant density just before harvesting per 1 m^2 — *Zagęszczenie roślin na 1 m^2 przed zbiorem*					
NPK + S	219	235	225	213	223
NPK + Mg	224	238	234	241	234
Mean — *Średnia*	221	237	230	227	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Silique number per plant — *Liczba łuszczyn na roślinie*					
NPK + S	63	73	77	83	74
NPK + Mg	59	63	80	74	69
Mean — *Średnia*	61	68	78	82	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – 12 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 12*					
Number of seed per 1 silique — *Liczba nasion w łuszczynie*					
NPK + S	12.0	10.3	11.1	10.8	11.1
NPK + Mg	10.9	10.9	10.1	10.9	10.7
Mean — *Średnia*	11.5	10.7	10.7	10.9	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Weight of 1000 seeds — *Masa 1000 nasion* [g]					
NPK + S	1.46	1.40	1.36	1.38	1.40
NPK + Mg	1.41	1.40	1.36	1.37	1.39
Mean — *Średnia*	1.44	1.40	1.36	1.37	
LSD (α=0,05): before sowing fertilization – n. s.; nitrogen top dressing – 0.3 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 0,3*					

[1] — urea at the beginning of blooming — *mocznik na początku kwitnienia*
[2] — 6% urea solution at full of blooming — *6% roztwór mocznika w pełni kwitnienia*
n. s. — not significant *r. n. — różnice nieistotne*

The smallest number of siliques was set on plants from treatment without nitrogen top dressing. Application of nitrogen at the start of blooming at the rate of 20 kg·N ha^{-1} increased number of set siliques on plant by 10 per cent.

Tabela 4

Seed yield of false flax — *Plon nasion lnianki* [tons ha^{-1}]

Before sowing fertilization *Nawożenie przedsiewne*	Nitrogen top dressing — *Nawożenie pogłówne azotem* [kg ha^{-1}]				Mean *Średnia*
	0	20 (solid fertilizer[1]) *(nawóz stały[1])*	35 (solid fertilizer[1]) *(nawóz stały[1])* + 5 (solution[2]) *(roztwór[2])*	40 (solid fertilizer[1]) *(nawóz stały[1])*	
NPK + S	1.74	1.92	2.07	2.14	1.97
NPK + Mg	1.62	1.89	2.05	2.14	1.92
Mean — *Średnia*	1.68	1.90	2.06	2.14	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – 0.2					
NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 0.2					

[1] — urea at the beginning of blooming — *mocznik na początku kwitnienia*
[2] — 6% urea solution at full of blooming — *6% roztwór mocznika w pełni kwitnienia*
n. s. — not significant *r. n. — różnice nieistotne*

Application of nitrogen at the rate of 40 kg·N ha^{-1} irrespectively of the form of the fertilizer resulted in significant increase of siliques number (by 28–34%) comparing to control. Number of seed per fruit was not modified by ferilization treatments. Weight of 1000 seeds was differentiated by nitrogen top dressing. The highest value of weight of 1000 seeds (1.44 g) was noted for the control treatment. Application of nitrogen as the top dressing decreased 1000 seed weight by 3 and 6% in relation to control for rate of 20 and 40 kg ha^{-1}, respectively. Split of top dressing nitrogen rate did not affect this value.

In 1997 yield of false flax seeds ranged from 2.3 to 2.9 tons ha^{-1}. In the second season of the studies yield was lower by 40 per cent whereas in 1999 yield of false flax seeds was lower by 30 per cent comparing to the season 1997 and reached to 1.5–1.9 tons ha^{-1}.

The tendency towards higher yield (by 3 per cent) of false flax seeds under the effects of sulphur fertilization compared with magnesium application was found. Level of pre sowing nitrogen application (40 kg N ha^{-1}) should be considered as too low because application of 20 kg N ha^{-1} as a top dressing significantly (by 13 per cent) increased seed yield. Further increase was found when the next rate 20 kg N ha^{-1} was applied. Application of the rate of 40 kg N ha^{-1} as solid urea was more favourable than application of part of the rate in urea solution. Similar results were achieved by Budzyński and Jankowski (1999). According to Dembiński (1975) false flax grown at the rate of 40 kg N ha^{-1} gave yield higher by 33% comparing to control.

Crambe

Method of pre-sowing fertilization did not affect morphological features of crambe. The tendency towards lower stem as nitrogen rates increased was observed. Low plants density of the unit of plot area resulted in high degree of branching from 11 to 14 branches per plant. Crambe was resistant to lodging. Stand deflection in all seasons of studies did not exceed 10 per cent and was not related to method of top dressing.

Table 5

Morphological features of crambe plants — *Cechy morfologiczne roślin katranu*

Before sowing fertilization *Nawożenie przedsiewne*	Nitrogen top dressing — *Nawożenie pogłówne azotem* [kg ha^{-1}]				Mean *Średnia*
	0	20 (solid fertilizer[1]) *(nawóz stały[1])*	35 (solid fertilizer[1]) *(nawóz stały[1])* + 5 (solution[2]) *(roztwór[2])*	40 (solid fertilizer[1]) *(nawóz stały[1])*	
Height of plants just before harvesting — *Wysokość roślin przed zbiorem* [cm]					
NPK + S	103	101	101	101	101
NPK + Mg	104	103	102	98	101
Mean — *Średnia*	103	102	102	100	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Base stem diameter — *Średnica podstawy łodygi* [mm]					
NPK + S	7.8	7.9	7.4	8.1	7.8
NPK + Mg	8.1	7.7	8.3	7.5	7.9
Mean — *Średnia*	7.9	7.8	7.9	7.8	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Number of fruit bearing branches per 1 m^2— *Liczba odgałęzień owoconośnych na 1 m^2*					
NPK + S	12.4	12.7	13.6	14.0	13.2
NPK + Mg	12.9	12.2	14.0	11.5	12.7
Mean — *Średnia*	12.6	12.4	13.8	12.8	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Stand deflection (per cent) — *Pochylenie łanu [%]*					
NPK + S	9	7	9	8	8
NPK + Mg	9	5	10	8	8
Mean — *Średnia*	9	6	10	8	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					

[1] — urea at the beginning of blooming — *mocznik na początku kwitnienia*
[2] — 6% urea solution at full of blooming — *6% roztwór mocznika w pełni kwitnienia*
n. s. — not significant *r. n. — różnice nieistotne*

Yield components of crambe were related neither to method of pre-sowing fertilization nor to top dressing rate and method of application (Table 6). High degree of branching resulted in setting of high number of fruit (282–433 per plant). The tendency towards setting of higher number of fruits per plant in the result of top dressing with nitrogen was observed. Split of top dressing rate and application of 6% urea solution made this tendency statistically significant. The highest weight of 1000 fruits of crambe was noted in the treatment with application of the rate 20 kg N ha^{-1} as a top dressing. Increasing of the nitrogen rate resulted in reduction of this parameter.

Table 6

Yield components of crambe seeds — *Składniki plonu nasion katranu*

Before sowing fertilization *Nawożenie przedsiewne*	Nitrogen top dressing — *Nawożenie pogłówne azotem* [kg ha^{-1}]				Mean *Średnia*
	0	20 (solid fertilizer[1]) *(nawóz stały[1])*	35 (solid fertilizer[1]) *(nawóz stały[1])* + 5 (solution[2]) *(roztwór[2])*	40 (solid fertilizer[1]) *(nawóz stały[1])*	
Plant density just before harvesting (per 1m^2) — *Zagęszczenie roślin na 1 m^2 przed zbiorem*					
NPK + S	53	57	53	53	54
NPK + Mg	51	50	52	54	58
Mean — *Średnia*	52	54	53	53	
LSD (α = 0,05): before sowing fertilization– n. s.; nitrogen top dressing – n. s. *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – r. n.*					
Number of siliques per 1 plant — *Liczba łuszczyn na roślinie*					
NPK + S	282	343	434	391	363
NPK + Mg	358	340	393	339	357
Mean — *Średnia*	320	342	413	365	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – 59 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem – 59*					
Weight of 1000 fruits — *Masa 1000 nasion* [g]					
NPK + S	6.7	6.9	6.8	6.8	6.8
NPK + Mg	6.8	7.1	6.7	6.9	6.9
Mean — *Średnia*	6.7	7.0	6.8	6.8	
LSD (α = 0.05): before sowing fertilization – n. s.; nitrogen top dressing – 0.2 *NIR (α = 0,05): nawożenie przedsiewne – r. n.; nawożenie pogłówne azotem– 0,2*					

[1] — urea at the beginning of blooming — *mocznik na początku kwitnienia*
[2] — 6% urea solution at full of blooming — *6% roztwór mocznika w pełni kwitnienia*
n. s. — not significant *r. n. — różnice nieistotne*

Yield level of crambe seeds appeared to be rather variable in season of studies. In 1997 1.26 ha^{-1} tons was noted. In the second year yield was lower by 50 per cent comparing to previous year. Favourable weather conditions in 1999 resulted in obtaining high yield of crambe seeds i.e. 1.38 ha^{-1}. Favourable effects of nitrogen given as top dressing on crambe yield were observed in seasons of better weather pattern. The lowest yield was formed in 20 kg nitrogen rate. However, considering the interaction of years × fertilization, it must be stated that in the 1st cycle of studies, top dressing application of 20 and 40 kg N in solid form resulted in 28–36% yield growth. Crambe reacted more favourably by yield growth to the split of nitrogen top dressing dose (in solid form and in solution). In the 2nd years of studies crambe yielded at statistically equal level, irrespectively of the method of nitrogen top dressing. In the 3rd year, the application of 20 and 40 kg N in solid form resulted in 7–10% yield growth in comparison to the plots where top dressing was not applied. The application of 40 kg N in solid form and in solution resulted in 21% yield growth in comparison to the control.

Table 7

Crambe seed yield [tons ha^{-1}] — *Plon nasion katranu*

Before sowing fertilization *Nawożenie przedsiewne*	Season of the studies *Okres badań*	Nitrogen top dressing — *Nawożenie pogłówne azotem* [kg ha^{-1}]				Mean *Średnia*
		0	20 (solid fertilizer[1]) *(nawóz stały[1])*	35 (solid fertilizer[1]) *(nawóz stały[1])* + 5 (solution[2]) *(roztwór[2])*	40 (solid fertilizer[1]) *(nawóz stały[1])*	
NPK + S	1	0.68	1.36	1.58	1.45	1.27
	2	0.64	0.66	0.62	0.62	0.64
	3	1.32	1.38	1.57	1.41	1.42
	x	0.88	1.13	1.26	1.16	1.11
NPK + Mg	1	1.26	1.12	1.41	1.18	1.24
	2	0.67	0.51	0.60	0.62	0.60
	3	1.19	1.31	1.49	1.36	1.34
	x	1.04	0.98	1.17	1.05	1.06
Mean — *Średnia*		0.96	1.06	1.21	1.11	
LSD (α = 0.05): before sowing fertilization — *nawożenie przedsiewne* – n. s. nitrogen top dressing — *nawożenie pogłówne azotem* – 0.1 years × nitrogen top dressing — *lata × nawożenie pogłówne azotem* – 0.1						

[1] — urea at the beginning of blooming — *mocznik na początku kwitnienia*
[2] — 6% urea solution at full of blooming — *6% roztwór mocznika w pełni kwitnienia*

Better results of sulphur application was noted comparing to magnesium in terms of crambe yield. Application of the rate of 25 kg S ha^{-1} resulted in yield increase by 5% comparing to pre-sowing by NPK and magnesium. Budzyński and Jankowski (1999) reported that crambe responded similarly to pre-sowing application of NPK + S and nitrogen top dressing.

Conclusions

- Sulphur at the rate of 25 kg S ha^{-1} and magnesium at the rate of 5 kg Mg ha^{-1} applied together with NPK (125 kg) did not significantly affect yield of generative organs of false flax and crambe.
- Spring false flax gave the highest yield (2.14 tons ha^{-1}) in treatment with pre-sowing nitrogen rate and nitrogen top dressing at the total rate of 80 kg N ha^{-1}. Application of 5 kg N ha^{-1} in urea water solution did not differentiate seed yield.
- The best method of crambe fertilization with nitrogen appeared to be application of 40 kg N ha^{-1} before sowing and the same rate as top dressing split 35 kg N ha^{-1} as a solid urea + 5 kg N ha^{-1} as urea water solution.

Wnioski

- Siarka w dawce 25 kg S ha^{-1} i magnez w dawce 5 kg Mg ha^{-1} podawana łącznie z NPK (125 kg) nie wpłynęła istotnie na plon organów generatywnych lnianki jarej i katranu abisyńskiego.
- Lnianka jara nawożona przedsiewnie i pogłównie azotem w dawce całkowitej 80 kg N ha^{-1} dała najwyższy plon (2,14 tony ha^{-1}). Podawanie 5 kg N ha^{-1} w postaci roztworu mocznika nie wpłynęło na wielkość plonu.
- Najlepszą metodą nawożenia katranu abisyńskiego azotem okazało się podawanie 40 kg N ha^{-1} w okresie przedsiewnym i pogłównie taką samą dawką rozdzieloną na 35 kg N ha^{-1} w postaci mocznika i 5 kg N ha^{-1} w postaci jego roztworu.

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