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FAGOPYRUM (Buckwheat Newsletter) is open to everyone interested in buckwheat and will cover all aspects of buckwheat research: genetics, cytology, breeding, cultivation, nutrition, utilization, biochemistry and other. Scientific papers, reviews, research notes on work in progress or on results not yet published: comments and speculations related to buckwheat; list of stock materials wanted or available; lists of names, addresses and field of work of scientists who have expressed the desire to receive the Newsletter; lists of publications which are related to buckwheat and which have appeared during preceding years; announcements concerning the promotion of research on buckwheat (workshop, symposia, and so on); abstracts and/or contents of published papers/books on buckwheat; bibliographies and other information related to buckwheat or buckwheat research will be published. In order to facilitate the elaboration of the bibliography scientists are asked to send reprints of their own publications to the editor of Fagopyrum.

Front page photo: A fluorescence micrograph of a cross section taken from the tip of a buckwheat cv. Siva kernel, with visible embryonic axis and two cotyledons (illustration of the paper of Alicia de Francisco and Ivan Kreft in this issue of Fagopyrum).

KAZALO - CONTENTS

Fagopyrum 9 (1989): 4-9

Longevity of buckwheat seeds and their tolerance to desiccation

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Key words: conservation, *Fagopyrum esculentum*, germination, seed storage, seedling vigour, viability

Abstract

Buckwheat seeds were stored at different moisture contents and temperatures. Seed viability was extended by lowering moisture content and storage temperature confirming that long term seed storage is feasible. Viability constants, kv, C1 and C2 were determined as 5.3672, 0.1409 and 0.0490 respectively, which are similar to those of cereals. Parameters of seedling vigour generally showed good correlation with germination.

Introduction

The importance of the conservation of genetic resources for future breeding work has been widely recognized. However, due to the decrease in area and production of buckwheat, there has been no systematic programme for preserving buckwheat germplasm (Marshall and Pomeranz, 1983). Recently there has been a recovery in demand, and extensive exploration of the genetic diversity has started (Kreft, 1981; Ohnishi, 1986). Collections of buckwheat genotypes will need to be conserved. If the seed can tolerate drying and low temperature (Roberts 1973), seed storage is likely to be the best means of genetic conservation because this is a stage of minimal metabolism in the plant life cycle and seeds need relatively little storage space. Many seed-producing crop species can be stored for long periods without much loss of viability or serious genetic change.

The longevity of seeds during storage can be predicted from aging experiments, in which seeds are stored under constant moisture and temperature conditions and germination monitored over time. Roberts and Abdalla (1968) proposed the following equation to describe the relationship between the half life of seeds and their storage conditions,

$$\log P50 = kv - C_1m - C_2t$$

where, P50 is time in days taken for 50% of the seeds to lose viability, m is moisture content and t is storage temperature. Kv, C_1 and C_2 are constants for seed lot, moisture content and temperature respectively.

There are also various indirect ways of measuring seed deterioration. Abnormal seedlings represent deteriorative changes which have occured in the seed but which are not severe enough to prevent germination. In germination tests, only normal seedlings are usually considered (ISTA 1985). Seedling vigour as measured by root and shoot lengths, speed of germination and electroconductivity of the seed soak water can also be utilized as indicators of seed condition (Ellis and Roberts, 1981). Tetrazolium staining in some species shows the location of dead tissues, and charts for discrimination of viable and non-viable seed have been prepared (ISTA, 1985).

No attempts to predict the storage potential of buckwheat seeds have been found in the literature. Therefore, an accelerated aging experiment, using high storage moisture and temperature conditions was carried out to determine viability constants for the species and investigate feasibility of long term storage of the seeds. The effects of desiccation on viability were also examined.

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Material and methods

Seeds of common buckwheat (*Fagopyrum esculentum* Moench) cv. "Kyushu Zairai Hanadaka Soba", which has long been cultivated in the western part of Japan, were used. The mature seeds were harvested according to traditional methods and kept under ambient conditions for approximately six months. Seeds were divided into two lots, one was kept over silica gel in a desiccator for two days to obtain low moisture content and the other was kept over water in a desiccatorfor one day to raise the moisture content. The moisture content was determined using the high constant temperature oven method (ISTA, 1985). Seeds, in lots of 50, were packeted in laminated aluminium foil hermetically sealed, and were kept at 15, 25 and 35°C. They were sampled at 35, 60, 90 and 120 days of storage and additionally at 46 days for the high moisture content lot.

Germination was tested between paper towels (IBPGR, 1985a) and three replicates of 50 seeds were used for each test. Paper towels were positioned vertically in plastic boxes containing water and were covered with polythene to maintain humidity but allow air circulation. Seeds were incubated at 20°C in the dark. Germination was examined after seven days. Normal germination, abnormal seedlings, and mean radicle and hypocotyl lengths were assessed. Only seedlings having a well developed root system with primary and secondary roots and a hypocotyl terminating in a normal plumular bud, vigourous enough to remove the seed coat, were regarded as normal and measured. Seeds showing no sign of germination were regarded as dead. For the purpose of assessing the germination speed, two replicates of 50 seeds were placed on moist filter paper in petri dishes and the mean time needed for germination was calculated in days.

Attempts were made to detect change in viability without germinating the seeds by using tetrazolium staining and electroconductivity measurements of the soak water of seeds. The latter might detect leakage of cell membranes.

Effects of desiccation were studied using seeds dried over silica gel for one, three and five weeks. The control sample was kept at room conditions. Seed lots were then divided into two, and half the seed was placed to germinate directly while the other half was rehydrated slowly in an atmosphere of 100% relative humidity at room temperature for two days and then germinated. Using three replicates of 50 seeds, germination and seedling parameters were assessed.

Results

The moisture content of stored seeds was 11.98 and 17.89%. The percentage germination, Table 1, for all combinations of storage conditions declined with increased storage period. Seeds stored at the higher moisture content and/or higher temperature showed more rapid decline. Statistical analyses of the germination data showed moisture content, storage temperature and storage period all had highly significant effects and there was an interaction between moisture content and temperature.

Table 1. Percentage germination of buckwheat seeds after storage. Each value is the mean of three replicates of fifty seeds.

Moisture content %	Temp. °C	Storage period - days 0	35	46	60	90	120
11.98	15	81.33	77.33	---	70.67	72.00	68.67
	25	81.33	76.67	---	68.00	66.67	60.00
	35	81.33	68.67	---	58.67	50.67	40.00
17.89	15	79.33	69.33	66.67	68.00	59.33	52.67
	25	79.33	48.67	44.67	36.00	24.00	12.00
	35	79.33	10.00	0.67	0.00	---	---

--- = no germination test carried out

Germination percentages, transformed to probit values were regressed against storage time and the significant survival curves, Figure 1, were used to calculate the time taken for seeds to reach 50% viability (P50 value). Substituting the P50 values, 91.9 (11.98%, 35°C), 129.3 (17.89%, 15°C), and 41.8 (17.89%, 25°C), which were obtained from the most significant curves, in the equation of Roberts and Abdalla (1968), $\log P50 = kv - C_1m - C_2t$, the viability constants kv, C_1 and C_2 were determined as 5.3672, 0.1409 and 0.0490, respectively. These constants can be used to predict the longevity of seeds in storage under any constant conditions.

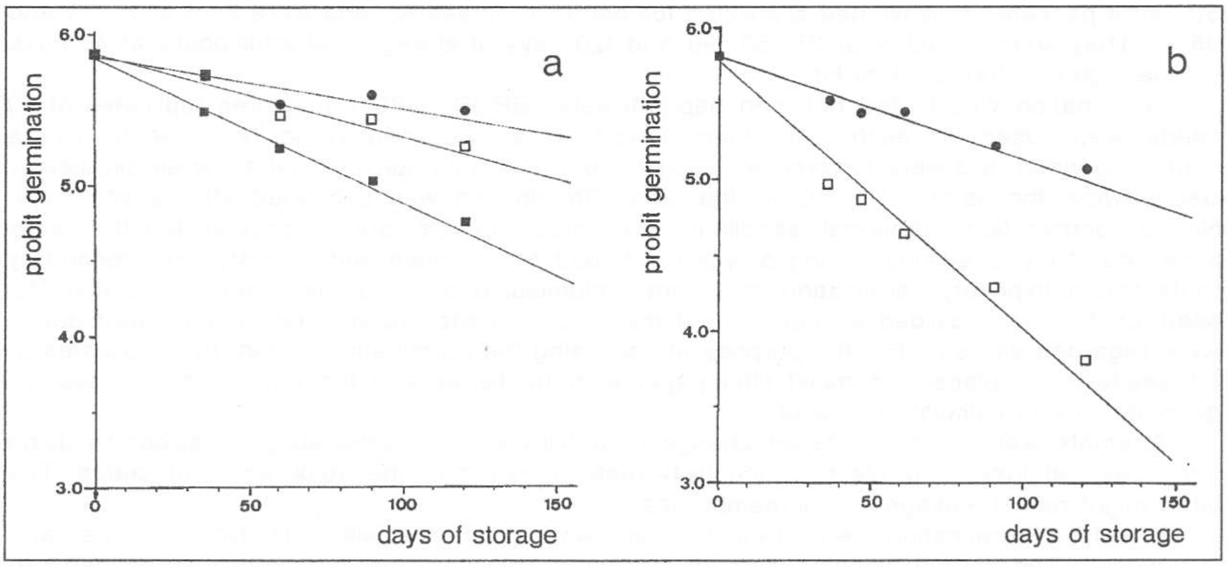

Fig. 1. Survival curves for seeds stored at 11.98 (a) and 17.89 (b) moisture content.
● = 15°C; □ = 25°C; ■ = 35°C

Abnormalities observed in buckwheat seedlings were a lack of primary root, swollen radicle, watery shoot and attached pericarp. A summary of the percentage of abnormal seedlings produced from stored seeds, Table 2, shows that generally there was an increase with storage period as germination percentage declined. However, this trend applied only when 50% or more of the seeds germinated normally. When germination percentage was less than 50% abnormal seedlings also declined. This observation supports the hypothesis that abnormalities in stored seeds probably lead to eventual loss of viability.

Table 2. Mean percentage of abnormal seedlings after storage.

Moisture content %	Temp. °C	Storage period - days 0	35	46	60	90	120
	15	7.33	12.67	---	14.67	15.33	16.67
11.98	25	7.33	10.67	---	14.00	14.67	17.33
	35	7.33	18.00	---	20.67	25.33	22.67
	15	13.33	15.33	20.00	16.00	26.00	21.33
17.89	25	13.33	24.00	27.33	23.33	22.67	12.67
	35	13.33	6.67	0.00	0.00	---	---

Both the mean radicle and hypocotyl length measurements declined with storage period, but only in the case of hypocotyls was there a statistically significant effect, Table 3. However both high moisture content and storage temperature significantly reduced radicle and hypocotyl length. The data suggest that hypocotyl length was more sensitive to storage conditions and served as a better indicator of deterioration than radicle length in this species.

The time taken for germination of seeds generally increased with higher moisture content, higher storage temperature and storage period.

There was no evidence of a good relationship between seed deterioration and electroconductivity measurements of the soak water of seeds. Tetrazolium staining did not discriminate between viable and inviable buckwheat seeds effectively.

Table 3. Mean radicle and hypocotyl lengths (cm) of normal seedlings after storage.

	Radicle length			Hypocotyl length		
	Storage temperature °C					
Moisture content %	15	25	35	15	25	35
11.98	11.40	11.59	10.62	9.60	9.43	8.42
17.89	11.51	10.10	9.15	9.96	7.96	7.43

Correlations were made between the five parameters of deterioration studied, Table 4. There was generally a highly significant correlation except for abnormal seedlings. Although overall the data for abnormal seedlings did not show any good correlation with other parameters when only data from treatments giving 50% or higher germination were considered, the negative correlation was significant.

Desiccation down to 4.6% had no adverse effect on buckwheat seeds, Table 5, and placing seeds of low moisture content directly in water did not harm germination or seedling growth.

Table 4. Correlations between the different parameters of deterioration after storage.

	1 Germ. percentage	2 Abn. seedlings	3 Rad. length	4 Hypo. length	5 Germ. speed
1		-0.020ns	0.908**	0.830**	-0.831**
2			-0.066ns	-0.108ns	0.138ns
2'	-0.893**		-0.571**	-0.434*	0.552**
3				0.864**	-0.836**
4					-0.849**

2' = data from samples with 50% or higher germination;
** = significant at 1% level, * = significant at 5% level,
ns = not significant

Table 5. Mean germinate percentage, abnormal seedlings, radicle length, hypocotyl length and germination time after desiccation and slow and rapid rehydration

Moisture Content (%)	Germination (%) (1)	(2)	Abnormal Seedlings (%) (1)	(2)	Radicle length (cm) (1)	(2)	Hypocotyl length (cm) (1)	(2)	Germination time (days) (1)	(2)
13.91 (Control)	71.33		14.00		10.66		8.49		3.24	
10.18	70.67	67.33	16.00	18.00	10.83	11.73	8.20	10.09	3.04	2.89
6.18	67.33	68.67	15.33	16.77	10.70	11.05	8.15	9.87	3.11	3.01
4.61	70.00	67.33	12.67	18.67	11.08	11.15	8.15	8.32	3.19	2.89

(1) rapid rehydration, (2) slow rehydration.

Discussion

This accelerated aging experiment has confirmed that buckwheat seeds are 'orthodox' with regard to storage behaviour, i.e. longevity was prolonged by reducing moisture content and storage temperature.

From the viability constants obtained, the storage potential for this species (kv = 5.3672) is similar to that of major cereals (rice, 5.680; wheat, 5.067) reported by Roberts and Ellis (1977). The ratio of the two viability constants C_1 and C_2 was 2.87, which means that 1% drop in moisture content has the equivalent effect of 2.87°C reduction of storage temperature. This ratio is also similar to that of rice and wheat, 3.19 and 2.16, respectively. This result suggests that although moisture content is an important factor to be reduced, storage temperature, which could span a wider range of values than moisture content, must be regulated, and its reduction is also very important.

Using the constants calculated here, a moisture content of 16%, which is the maximum value suggested by Marshall and Pomeranz (1983) for agronomic purposes, and a storage temperature of 15°C, the theoretical half life (P50 value) of the seeds would be 238 days and this coincides with the period between harvest and sowing in agricultural practice. Since 50% germination is not satisfactory however, a lower moisture content during storage is recommended.

The recommended conditions for seed storage in gene banks (IBPGR 1985b) are 5% moisture content and -20°C. Under these conditions, the half life of seeds would be 1203 years. This suggests that the long term conservation by means of seed storage is feasible for buckwheat germplasm. No adverse effects of desiccation were observed down to 4.61% seed moisture content so the IBPGR recommendation appears appropriate. No investigation of the effects of sub-zero temperature has been carried out, but at low moisture content adverse effects are not expected.

The deterioration of seeds in storage is clearly a gradual process and the increase in seedling abnormalities, the decrease in radicle and hypocotyl lengths and reduced speed of germination correlated with a decreasing germination support the inference that physiological changes in the seeds during storage accumulate affecting seedling growth until the point is reached at which germination itself can not proceed. A good correlation between all the parameters of seedling vigour and percentage germination showed that these measurements serve as good indicators of the loss of viability but there was no evidence to support the view that seedling parameters were more sensitive measures of deterioration than germination.

While the electroconductivity measurements of seed soak water generally increased with higher moisture content and storage temperature they did not prove to be reliable indicators of seed deterioration for this species. A large part of the buckwheat seed is endosperm consisting of dead cells, and this may account for why leakage from cells is not well correlated with the conditions of living tissues. Similarly, the tetrazolium staining test cannot be recommended for this species.

For the long term, buckwheat seeds can be stored at low moisture content and low temperature but preferably good quality seed should be stored and harvest and pre-harvest factors, including seed maturity, which affect seed quality and thus storage behaviour, require investigation.

Acknowledgement

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References

Ellis R.H. and Roberts E.H. 1981. The quantification of aging and survival in orthodox seeds. Seed Sci. & Tech. 9: 373-409.

International Board for Plant Genetic Resources (IBPGR) 1985a Handbook of seed technology for gene banks: No3 Vol.II. Compendium of specific germination information and test recommendations. IBPRG., Rome, Italy.

International Board for Plant Genetic Resources (IBPGR) 1985b Report of the committee on seed storage, the third meeting. IBPGR, Rome, Italy.
International Seed Testing Association (ISTA) 1985. International rules for seed testing. Seed Sci. & Tech. 13: 307-520.
Kreft I. 1981. Starting point for buckwheat breeding in Yugoslavia. Proc. 1st. Symp. Buckwheat at Ljubljana: 7-15.
Marshall H.G. and Pomeranz Y. 1983. Buckwheat; Description, breeding, production and utilization. *In* Advances in Cereal Science and Technology Vol V: pp 157-210.
Ohnishi O. 1986. Evaluation of world buckwheat varieties from the viewpoints of genetics, breeding and the origin of buckwheat cultivation. Buckwheat Research, Proc. 3rd. Intl. Symp. Buckwheat at Putawy. Part 1: 198-213.
Roberts E.H. 1973. Predicting storage life of seeds. Seed Sci. Tech. 1: 499-514.
Roberts E.H. and Abdalla F.H. 1968. The influence of temperature, moisture and oxygen on period of seed viability in barley, broad beans, and peas. Ann. Bot. 32: 97-117.
Roberts E.H. and Ellis R.H. 1977. Prediction of seed longevity at subzero temperature and genetic resources conservation. Nature 268: 431-433.

MOŽNOSTI SHRANJEVANJA SEMEN AJDE IN ODPORNOST PRI IZSUŠEVANJU

Izvleček

Semena ajde so bila spravljena pri različnih vlažnostih in temperaturah. Z nižjo vlažnostjo in nižjo temperaturo shranjevanja se je bolje ohranila življenjska sposobnost semen, kar je potrdilo, da je možno semena shranjevati dolgoročno. Konstante življenjske sposobnosti kv, C1 in C2 so bile 5.3672, 0.1409 oziroma 0.0490, kar je podobno kot pri žitih. Parametri življenjske sposobnosti rastlinic so v povezavi s kalivostjo.

Fagopyrum 9 (1989): 10-14

Mutation studies in buckwheat (*Fagopyrum*)
I. Effect of gamma rays on germination

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Key words: emergence, *Fagopyrum esculentum*, *Fagopyrum tataricum*, radiation dose

Abstract

Seeds of two species of *Fagopyrum* were treated with gamma rays at a dose level ranging between 0 to 40 kR, from a Co^{60} source. Total germination capacities of both the species in M_1 and M_2 were appreciated by low doses of gamma radiations up to 15 kR while it was progressively reduced at higher doses beyond 15 kR. However in M_3, unlike M_1 and M_2, the rise in the percentage of total emergence even up to 15 kR was not significant. Low doses up to 15 kR hastened emergence while higher doses delayed it. *F. tataricum* took lesser time in expansion of first true leaf as compared to *F. esculentum*. There was gradual and consistent decrease in the percentage of surviving plants as the radiation dose increased from 0 to 40 kR.

Material and Methods

Dry seeds of two species of buckwheat viz. *F. esculentum* (IC 49666) and *F. tataricum* (IC 13374), at 13.75% and 12.50% moisture content respectively, were exposed to 5, 10, 15, 20, 25, 30 and 40 kR doses of gamma rays from Co^{60} source in gamma irradiation chamber of National Botanical Research Institute, Lucknow at the dose rate of 51.7 sec/kR at 31°C.

500 seeds of each treatment as well as that of control of both the species were sown in well prepared plots. The row to row distance was 50 cm while plant to plant distance was 15 cm. Generation from treated seeds was M_1 generation.

Seeds obtained from M_1 were collected to grow M_2 and those of M_2 to grow, subsequently, the M_3 generation.

To ascertain the germination percentage, 250 seeds were placed on a moist filter paper in a petridish. The number of germinated seeds of each treatment was recorded on the 4th day when most of the radicles had attained a length of approx. 5 mm.

The emergence of seedlings in the field (emergence of cotyledonary leaves) was considered as days to field emergence.

Percent emergence was noted on the 15th day after sowing. The survival was recorded on 30th day after sowing.

The experiment was conducted in a completely randomized design with 16 treatments, combinations of two factors each at 2 and 8 levels respectively having 40 and 5 replications.

The data were statistically analysed by the method suggested by Douglas C. Montgomery (1984), using a personal computer.

Results

1. Results for M_1, M_2 and M_3 for both the species have been presented in Tables 1, 2 and 3.
2. Table 1 suggests that in M_1 generation *F. esculentum* took less time (8.2 days) in emergence than *F. tataricum* (9.8 days). 10 and 15 kR hastened the emergence whereas further increase in the radiation dose delayed emergence from 8.4 days at 20 kR to as much as 12.1 days at the highest dose (40 kR).

In M_2 the emergence was delayed even at 15 kR, although the difference was significant only in the case of *F. tataricum* at this level. M_3 was, more or less, similar to M_1 in both the species.

3. Table 2 reveals that in M_1 radiation treatment appreciated total germination from 89.5% to as much as 93.0% at 10 kR, a significant fall was recorded even at 15 kR.The total germination was progressively reduced from 87.0% at 15 kR dose level to as low as 34.5% in 40 kR.

Table 1: Days to field emergence.

DOSE RATE	M_1 F.esc.	M_1 F.tat.	M_1 MEAN	M_2 F.esc.	M_2 F.tat.	M_2 MEAN	M_3 F.esc.	M_3 F.tat.	M_3 MEAN
CONTROL	7.9	9.3	8.6	7.5	8.6	8.1	7.9	9.0	8.4
5 kR	7.6	9.0	8.4	7.5	8.3	7.5	7.4	8.9	8.2
10 kR	6.9	8.5	7.7	7.1	7.9	7.5	7.0	8.5	7.8
15 kR	6.5	8.9	7.7	7.4	8.7	8.1	6.7	8.8	7.8
20 kR	7.6	9.2	8.4	7.9	9.3	8.6	7.5	9.1	8.3
25 kR	8.5	9.5	9.0	8.3	10.0	9.2	8.3	9.6	8.9
30 kR	8.8	11.0	9.9	8.7	10.7	9.7	8.8	10.8	9.8
40 kR	11.5	12.8	12.1	11.5	12.5	12.0	11.3	11.2	11.3
MEAN	8.2	9.8	9.0	8.2	9.5	8.8	8.1	9.5	8.8

	M_1 S.E(Mean)	M_1 C.D.at 5% P	M_2 S.E(Mean)	M_2 C.D.at 5% P	M_3 S.E(Mean)	M_3 C.D.at 5% P
S	±0.055	0.154	±0.049	0.137	±0.054	0.153
T	±0.109	0.309	±0.098	0.247	±0.108	0.305
S x T	±0.155	0.436	±0.138	0.388	±0.153	0.432

Table 2: Total emergence (%).

DOSE RATE	M_1 F.esc.	M_1 F.tat.	M_1 MEAN	M_2 F.esc.	M_2 F.tat.	M_2 MEAN	M_3 F.esc.	M_3 F.tat.	M_3 MEAN
CONTROL	72.8	69.8	71.3	68.9	66.6	67.7	74.1	71.0	72.6
	(91.0)	(88.0)	(89.5)	(87.0)	(84.0)	(85.5)	(92.0)	(89.0)	(90.5)
5 kR	73.6	71.0	72.3	72.7	69.8	71.2	73.7	72.0	72.8
	(92.0)	(89.0)	(90.5)	(91.0)	(88.0)	(89.5)	(92.0)	(90.0)	(91.0)
10 kR	77.2	72.8	75.0	74.8	70.7	72.7	71.7	72.6	72.2
	(95.0)	(91.0)	(93.0)	(93.0)	(89.0)	(91.0)	(90.0)	(91.0)	(90.5)
15 kR	73.6	65.4	69.5	71.8	63.5	67.6	72.6	73.9	73.2
	(92.0)	(82.0)	(87.0)	(90.0)	(80.0)	(85.0)	(91.0)	(92.0)	(91.5)
20 kR	66.5	62.2	64.4	69.8	62.8	66.3	68.1	63.5	65.8
	(84.0)	(78.0)	(81.0)	(88.0)	(79.0)	(83.5)	(86.0)	(80.0)	(83.0)
25 kR	56.8	56.2	56.5	60.7	53.7	57.2	60.6	58.7	59.7
	(70.0)	(69.0)	(69.5)	(76.0)	(65.0)	(70.5)	(76.0)	(73.0)	(74.5)
30 kR	52.5	52.0	52.2	55.7	51.3	53.5	56.9	56.2	56.5
	(63.0)	(62.0)	(62.5)	(68.0)	(61.0)	(64.5)	(70.0)	(69.0)	(69.5)
40 kR	34.3	37.4	35.9	33.9	37.8	35.8	32.5	37.9	35.2
	(32.0)	(37.0)	(34.5)	(31.0)	(38.0)	(34.5)	(29.0)	(38.0)	(33.5)
MEAN	63.4	60.8	62.2	63.5	59.5	61.6	63.8	63.2	63.5
	(77.3)	(74.5)	(75.9)	(78.0)	(73.0)	(75.5)	(78.2)	(77.7)	(78.0)

	M_1 S.E(Mean)	M_1 C.D.at 5% P	M_2 S.E(Mean)	M_2 C.D.at 5% P	M_3 S.E(Mean)	M_3 C.D.at 5% P
S	±0.582	N.S.	±0.500	N.S.	±0.567	N.S.
T	±1.164	3.383	±1.000	2.821	±1.134	3.198
S x T	±1.647	N.S.	±1.415	N.S.	±1.604	N.S.

S = species; T = treatment; S x T = species x treatment interaction;
N.S. = not significant.

NOTE: Figures in parenthesis denote transformed back values in percentage.

In M_2 there was slight but significant increase in total emergence between control and 10 kR and thereafter the increase in dose of radiation resulted in sharp fall from 91.0% at 10 kR to as low as 34.5% at 40 kR dose level. In M_3, unlike M_1 and M_2 generations, the rise in the rate of total emergence up to 15 kR was not significant. But it showed a steep fall from 83.0% at 20 kR dose to as low as 33.5% at 40 kR dose.

4. As is evident from Table 3, a gradual and consistent decrease in percentage of surviving plants was observed with increase in radiation dose. The survival was 91.5% on 30th day after sowing (DAS) in control whereas it was only 41.0% at 40 kR. The LD-50 for both the species under investigation was anything between 30 kR and 40 kR.

In M_2 in both *F. esculentum* and *F. tataricum* plants treated with 5 kR showed somewhat better survival than control.

Table 3: % plant survival on 30th DAS

DOSE	M_1			M_2			M_3		
RATE	F.esc.	F.tat.	MEAN	F.esc.	F.tat.	MEAN	F.esc.	F.tat.	MEAN
CONTROL	93.0	90.0	91.5	93.0	89.0	91.0	94.0	91.0	92.5
5 kR	91.0	89.0	90.0	94.0	91.0	92.5	96.0	93.0	94.5
10 kR	89.0	87.0	88.0	91.0	87.0	89.0	93.0	86.0	89.5
15 kR	86.0	83.0	84.5	89.0	80.0	84.5	87.0	87.0	87.0
20 kR	75.0	79.0	77.0	77.0	75.0	76.0	78.0	83.0	80.5
25 kR	70.0	73.0	71.5	68.0	63.0	65.5	63.0	72.0	67.5
30 kR	59.0	60.0	59.5	61.0	61.0	61.0	57.0	70.0	63.5
40 kR	43.0	39.0	41.0	47.0	38.0	42.5	48.0	41.0	44.5
MEAN	75.8	75.0	75.4	77.5	73.0	75.3	77.0	77.9	77.4

Discussion and conclusions

Alekseeva (1978) has discussed results and prospects of radiation induced mutagenesis in buckwheat breeding. She has examined the conditions under which mutations occur. She stated that the main problem in future breeding work will be to reinforce the effects of directional selection in order to make the most effective use of radiation induced mutagenesis.

The observations on seed germination and field emergence in the two species with reference to different doses of gamma rays were not consistent. Fig. 1 a & b would indicate that lower doses in both *F. esculentum* and *F. tataricum* reduced the time of field emergence and the optimum dose for both the species was adjudged to be 10 kR. Though from the figures there appear a regular curve from the control to 30 kR, the difference in the days to field emergence between 30 and 40 kR were more marked as compared to any other two subsequent doses.

Fig. 1 a

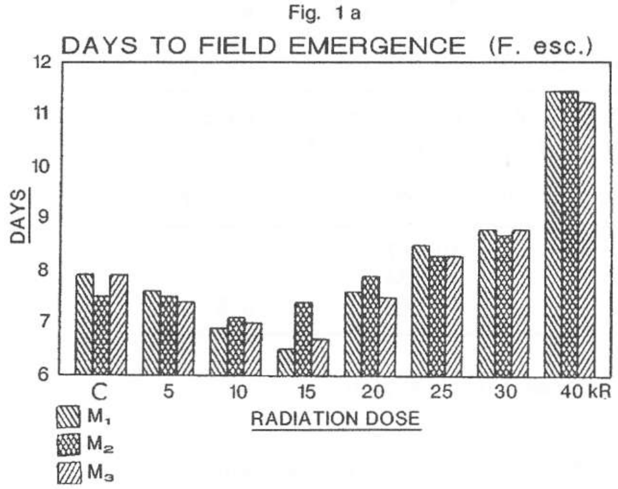
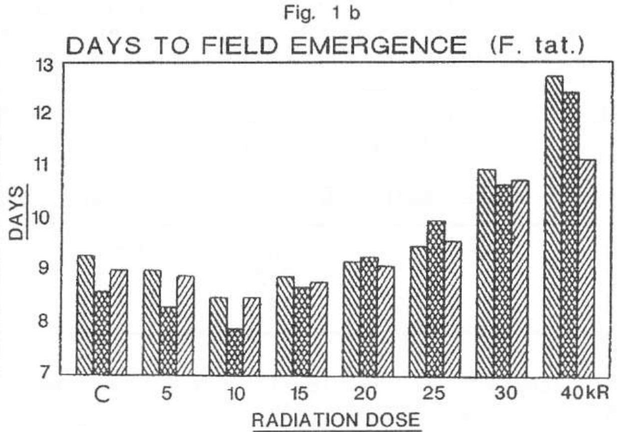


Fig. 1 b



Sharma and Boyes (1962) have found a very highly significant reduction in the length of sprouting period after treatment with 5 kR to 20 kR X-rays and N-10 to N-25 doses of thermal neutrons. According to them the seed germination was significantly delayed by about 1 day (0.88) by 40 kR X-rays (X-40) treatment, whereas the remaining treatments (X-30 and N-33.5) showed no statistically significant deviations. As regards the total emergence, Fig. 2 a & b would suggest that the optimum dose for both *F. esculentum* and *F. tataricum* was 10 kR and from 15 kR to 40 kR there was consistent and steady fall in total emergence. It was noteworthy that the emergence of radicle from the seeds was quicker at higher doses as compared to lower doses.

Raghuvanshi and Singh (1974) have observed that the rate of dividing cells in the radicle during the first few days was faster at higher doses as compared to that at lower doses as well as control. This may probably be the reason for quick emergence of radicles from the seeds exposed to acute doses.

Reduction in seed germination percentage has been reported by several early workers also and the observations of Bhaskaran and Swaminathan (1961), Banerjee (1963), Goud (1967), Swaminathan and Natarajan (1959) on wheat as well as in other plants support the present study on *Fagopyrum*.

Fig. 2 a

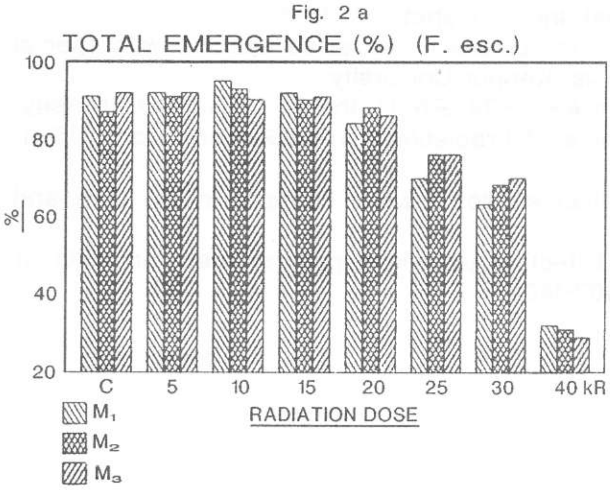
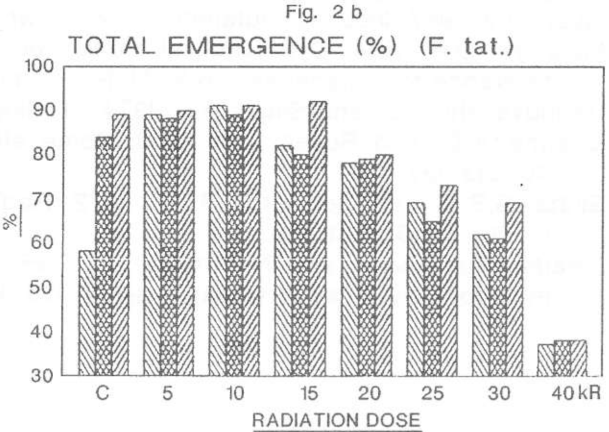


Fig. 2 b



Observations on plant survival recorded on the 30th DAS in different sets of treatments have indicated that there was a definite manifestation of damage due to treatments on germination and there was a gradual fall in percentage plant survival with increase in the dose rate, from the very beginning. Fig. 3 a & b suggest that in most of the cases the percentages

Fig. 3 a

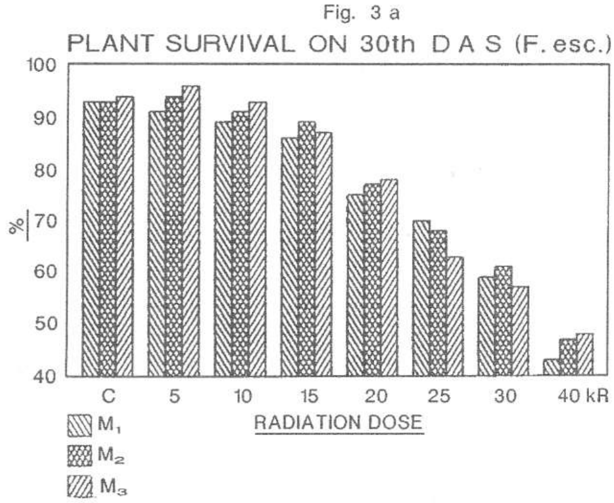
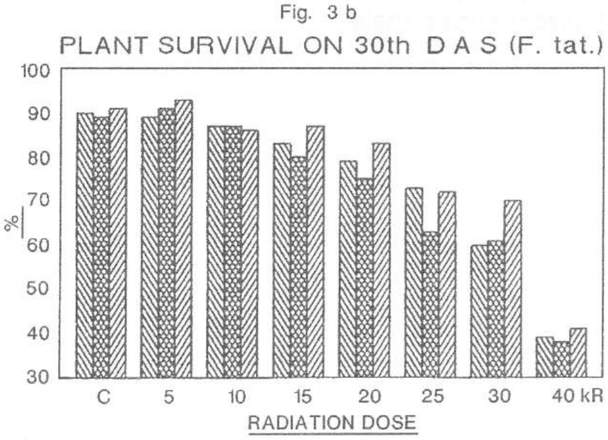


Fig. 3 b



of surviving plants at different doses of gamma irradiations were more in M_3 generation than in M_1 and M_2 which are in agreement with the findings of Sinha and Godward (1972), Malaviya (1984) in lentils and Banerjee (1963) in breadwheat. Sinha and Godward (1972) have reported that 63% of total seedlings survived upto two leaf stage at 32 kR dose. The present study also indicates that LD-50 may be in between 30 kR and 40 kR for both *F. esculentum* and *F. tataricum*. Malaviya (1984), in lentil, reported LD-50 to be in between 10 and 20 kR for the variety 2327 and in between 20 and 30 kR for the variety 3991.

References

Alekseeva, E.S. 1978. Results and prospects of radiation induced mutagenesis in buckwheat breeding. Pt. Br. Abs. 48 (7).

Banerjee, S.K. 1963. Studies on the maximisation of induced mutation frequency in wheat. I.A.R.I., P.G. School; Ph. D. thesis.

Bhaskaran, S. and Swaminathan, M.S. 1963. Polyploidy and radiosensitivity in wheat and barley. Genetica 32: 1-32.

Douglas, C. Montgomery. Design and Analysis of Experiments. 2nd Ed. John Willey & Sons.

Goud, J.V. 1967. Induced mutations in bread wheat. Ind. J. Genet. 27: 40-45.

Malaviya, D.R. 1984. Cytogenetical studies on *Lens culinaris* and allied species with special reference to mutagenesis in lentil. Ph. D. thesis, Kanpur University.

Raghuvanshi, S.S. and Singh, A.K. 1974. cf. Singh A.K. 1974, Ph. D. thesis, Lucknow University.

Sharma, K.D. and Boyes, J.W. 1962. Some effects of irradiations on buckwheat. Can. J. Bot. 40: 213-237.

Sinha, S.S.N. and Godward, M.B.E. 1972. Radiation studies in *Lens culinaris*. Ind. J. Gen. and Pl. Br. 32 (3): 331-339.

Swaminathan, M.S. and Natarajan, A.T. 1959. Effect of ultraviolet pre-treatment on yield of mutations by X-ray in wheat. Science 130: 1407-1409.

RAZISKAVE MUTACIJ PRI AJDI (*FAGOPYRUM*)
I. VPLIV GAMA ŽARKOV NA KALIVOST

Izvleček

Semena navadne ajde in tatarske ajde so bila obsevana z gama žarki od 0 do 40 kR. S sevanjem je bila kalitev pri nizkih odmerkih do 15 kR pospešena, pri višjih odmerkih pa je kalivost hitro padala.

Fagopyrum 9 (1989): 15-22

Mutation studies in buckwheat (*Fagopyrum*)
II. Gamma ray induced chlorophyll mutations and vital mutation frequencies

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Key words: albina, *Fagopyrum esculentum*, *Fagopyrum tataricum*, leaf variegation, maculata, maturity, plant height, stem, yield

Abstract

In M_2 and M_3 generations of both *Fagopyrum esculentum* and *Fagopyrum tataricum* some viable and non-viable chlorophyll mutants were observed. Their frequencies and spectra were random. The most frequently appearing mutation was maculata while the least appearing was albina. *F. tataricum* was more mutation prone as compared to *F. esculentum*. Mutation frequencies on the basis of their appearance in M_2 and on the basis of segregation tendencies in M_3 proved to be maximum at 40 kR dose in both the species. Plant height (both in +ve and -ve directions) was the most mutation prone character and after plant height, the second most frequently appearing character was the appearance of leaf variegation. *F. tataricum* showed more variegated leaves as compared to *F. esculentum*. Yield was the least affected character in both the species. Five mutants - three in *F. esculentum* and two in *F. tataricum*, have been selected on the basis of their better all round performance over the control and some other desirable characters.

Material and methods

Seeds of two cultivated species of buckwheat viz. *F. esculentum* and *F. tataricum* were irradiated with gamma rays from a Co^{60} source at 5, 10, 15, 20, 25, 30 and 40 kR. Irradiated seeds along with control were sown in completely randomized plots.

Chlorophyll mutants: Immediately after the emergence of the first leaf, screening for different types of chlorophyll mutants was undertaken. The classification for different types of chlorophyll mutations was done on the basis of description given by Gustafsson (1940).

Mutation spectra: The spectra of viable mutations observed in *F. esculentum* and *F. tataricum* in M_2 and M_3 have been represented as follows:

1. Mutation affecting plant morphology:
 (a) Changes in leaf characteristics:
  (I) Narrow leaf
  (II) Broad leaf
  (III) Rolled leaf
  (IV) Variegated leaf
 (b) Changes in stem characteristics:
  (I) Tall
  (II) Dwarf
  (III) Stiff straw
  (IV) Weak straw
 (c) Changes in fertility:
  (I) Sterile
  (II) Semisterile
2. Mutations affecting period of maturity:
  (I) Early maturing
  (II) Late maturing

3. Drastic changes
4. Mutations affecting yield:
   (I) High yielding
   (II) Low yielding

Of the above 14 types spectrum has been given for only 8 types. The remaining 6 types of mutations whose frequency was not high enough have been pooled and shown in the last column of the Tables as "others".

Results and discussion

Chlorophyll mutations:

According to Gaul (1964), it is customary to use the chlorophyll mutation rate in the M_2 generation as a test of effectiveness of a definite radiation dose. Many workers regard them as test mutations for vital mutations. Usually it is tacitly assumed that their frequency is proportional to the mutation rate of vital mutations.

In the present study it was found that distribution of different types of chlorophyll mutations was random and there was no apparent correlation with treatment or the dose effect. Non-viable chlorophyll deficient mutants such as albina, however, did not show their appearance below dose of 25 kR in *F. esculentum* and below the dose of 20 kR in *F. tataricum* in either of the two generations i.e. M_2 or M_3. The most frequently appearing chlorophyll mutations happened to be maculata and striata and the least appearing was albina (Tables 1, 2, 3 and 4). Tables also indicate that on overall basis, *F. tataricum* proved to be more mutation prone (54 for M_2 and 67 for M_3) than *F. esculentum* (45 for M_2 and 49 for M_3). Roik and Alekseeva (1984) investigated chlorophyll mutations in buckwheat, their frequency and range. According to them lethal mutations, specially of the albina and xantha types predominated in M_2 but viable types were more frequent in M_3. Kurganova *et al.* (1982) have studied the functional activity of chloroplasts in relation to the action of gamma irradiations on seeds. The gamma irradiation of seeds with 0.5 kR increased the cyclic and non-cyclic phosphorylation of isolated buckwheat chloroplasts. Increased ATP content in plants from irradiated seeds was accompanied by activation of ATPase activity in the chloroplasts. Irradiation at 10 kR decreased these processes. The change in photosynthetic activity of chloroplasts may be the result of structural metabolic shift in seeds produced by irradiation. D'Amato *et al.* (1952); Bhatia and Swaminathan (1963); Ramanna and Natarajan (1965); Ramula (1970) and Sen (1979) have suggested that physiological disturbances in the growing plants or mutations of plastid genes leading to chlorophyll deficient chimeras may be the reason for such phenomenon. Chun *et al.* (1963) observed chloroplast DNA to be highly rich in G-C base pairs which may be selectively affected by mutagenesis resulting in chloroplast chimeras.

Table 1: Frequency and spectrum of chlorophyll mutation in M_2 in *F. esculentum*.

DOSE RATE	ALBINA	VIRIDIS	ALBO-VIRIDIS	STRIATA	MACULATA	TOTAL	MUTATION/1000
CONTROL	-	-	-	-	-	0	0.0
5 kR	-	-	-	2	3	5	10.6
10 kR	-	1	1	-	5	7	15.4
15 kR	-	-	2	3	3	8	18.0
20 kR	-	1	1	1	4	7	18.2
25 kR	-	1	1	2	2	6	17.6
30 kR	1	1	-	1	3	6	19.6
40 kR	1	2	-	-	3	6	25.5
TOTAL	2	6	5	9	23	45	125.0

Table 2: Frequency and spectrum of chlorophyll mutation in M_2 in *F. tataricum*.

DOSE RATE	ALBINA	VIRIDIS	ALBO-VIRIDIS	STRIATA	MACULATA	TOTAL	MUTATION/1000
CONTROL	-	-	-	-	-	0	0.0
5 kR	-	2	2	1	3	8	17.5
10 kR	-	2	1	2	3	8	18.3
15 kR	-	1	1	2	5	9	22.5
20 kR	-	2	-	1	4	7	21.3
25 kR	1	-	-	2	5	8	22.2
30 kR	1	1	1	1	4	8	26.2
40 kR	-	1	-	2	3	6	31.5
TOTAL	2	9	5	11	27	54	159.5

Table 3: Frequency and spectrum of chlorophyll mutation in M_3 in *F. esculentum*.

DOSE RATE	ALBINA	VIRIDIS	ALBO-VIRIDIS	STRIATA	MACULATA	TOTAL	MUTATION/1000
CONTROL	-	-	-	-	-	0	0.0
5 kR	-	-	2	2	3	7	14.5
10 kR	-	1	-	3	4	7	15.0
15 kR	-	1	-	3	3	7	16.0
20 kR	-	1	1	3	3	8	20.5
25 kR	-	2	1	-	4	7	22.2
30 kR	1	-	1	-	5	7	24.5
40 kR	1	-	-	1	4	6	25.0
TOTAL	2	5	5	12	26	49	137.7

Table 4: Frequency and spectrum of chlorophyll mutation in M_3 in *F. tataricum*.

DOSE RATE	ALBINA	VIRIDIS	ALBO-VIRIDIS	STRIATA	MACULATA	TOTAL	MUTATION/1000
CONTROL	-	-	-	-	-	0	0.0
5 kR	-	1	-	3	5	9	19.3
10 kR	-	3	1	2	3	9	20.9
15 kR	-	2	2	2	4	10	22.9
20 kR	-	1	2	1	7	11	26.5
25 kR	1	1	1	2	4	10	27.7
30 kR	2	1	1	1	6	11	31.4
40 kR	1	1	-	1	4	7	34.8
TOTAL	4	10	7	13	33	67	182.8

Mutation spectra for vital mutations:

The mutation spectra of *F. esculentum* and *F. tataricum* in M_2 and M_3 generations for some important morphological and reproductive attributes are presented in Fig. 1 a & b and Fig. 2 a & b respectively. In *F. esculentum* the most frequently appearing mutation was the appearance of leaf variegation in both M_2 and M_3. In *F. tataricum* the height (-ve) was found to be the most affected character in M_2, while appearance of leaf variegation was the close second. In M_3, however, the leaf variegation was found to be the most frequent character, while the height (-ve) was a close second. While in M_3 in *F. esculentum* the minimum appearing frequency was that of early maturing mutants, in all other cases it was that of high yielding mutants.

Fig. 1 a: MUTATION SPECTRUM IN M_2 IN *F. esculentum*

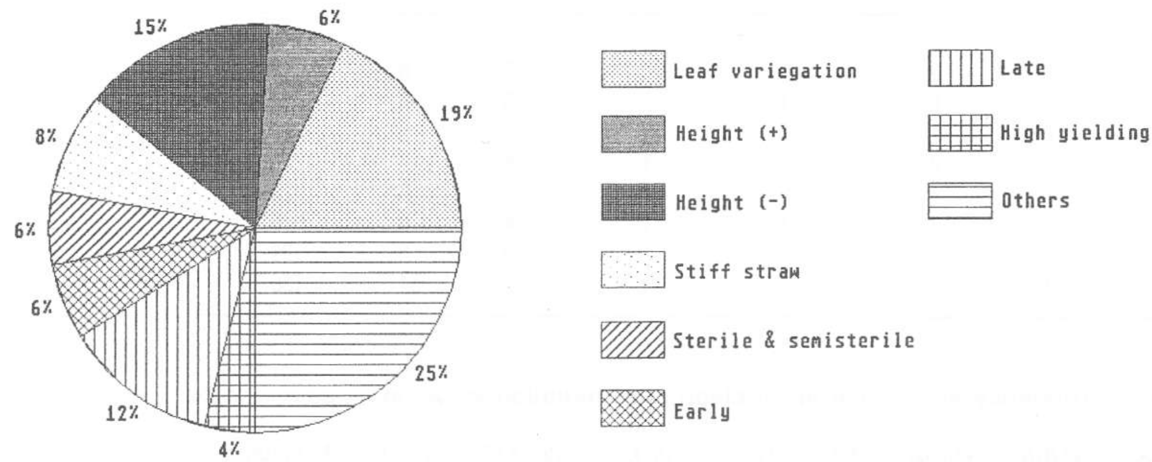

Fig. 1 b: MUTATION SPECTRUM IN M_2 IN *F. tataricum*

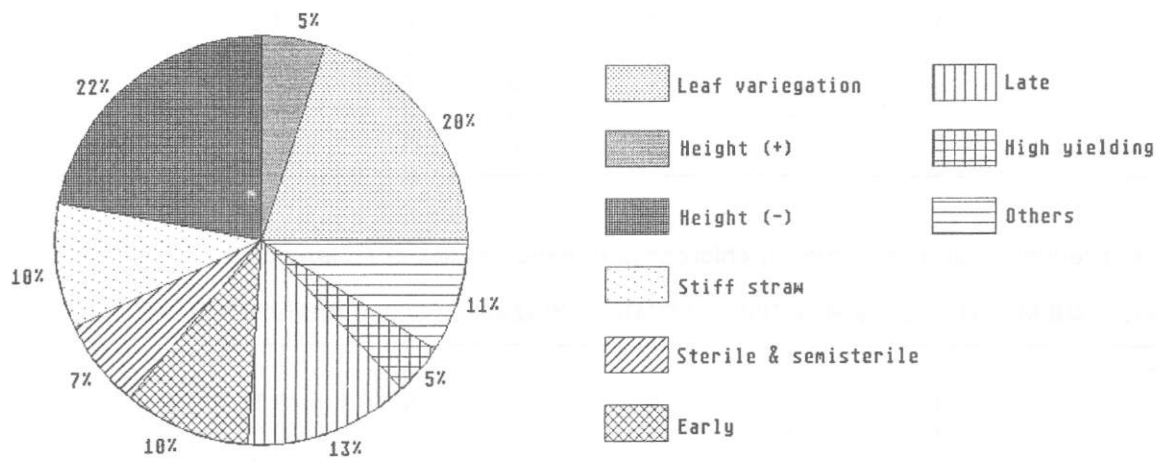

Fig. 2 a: MUTATION SPECTRUM IN M_3 IN *F. esculentum*

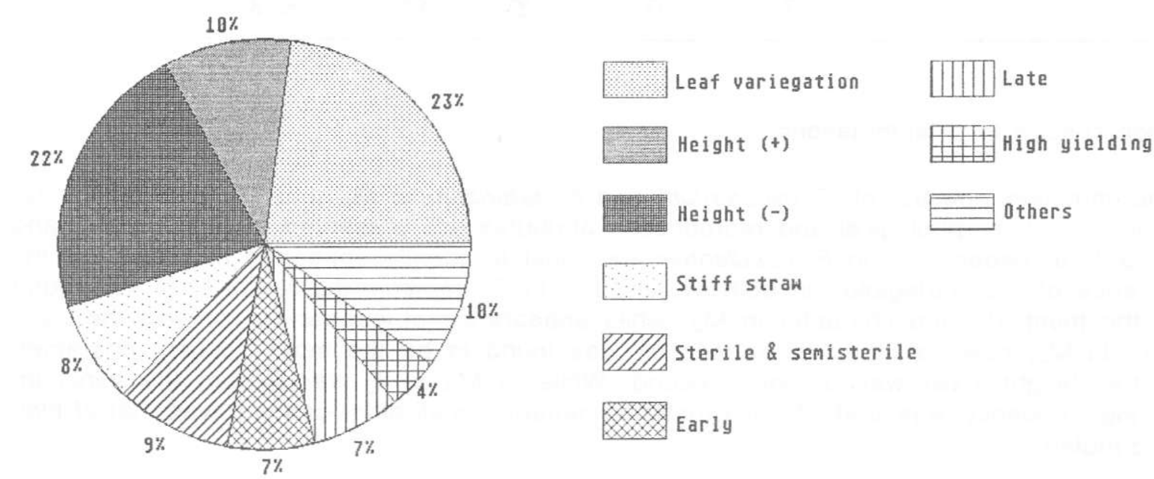

Fig. 2 b: MUTATION SPECTRUM IN M_3 IN *F. tataricum*

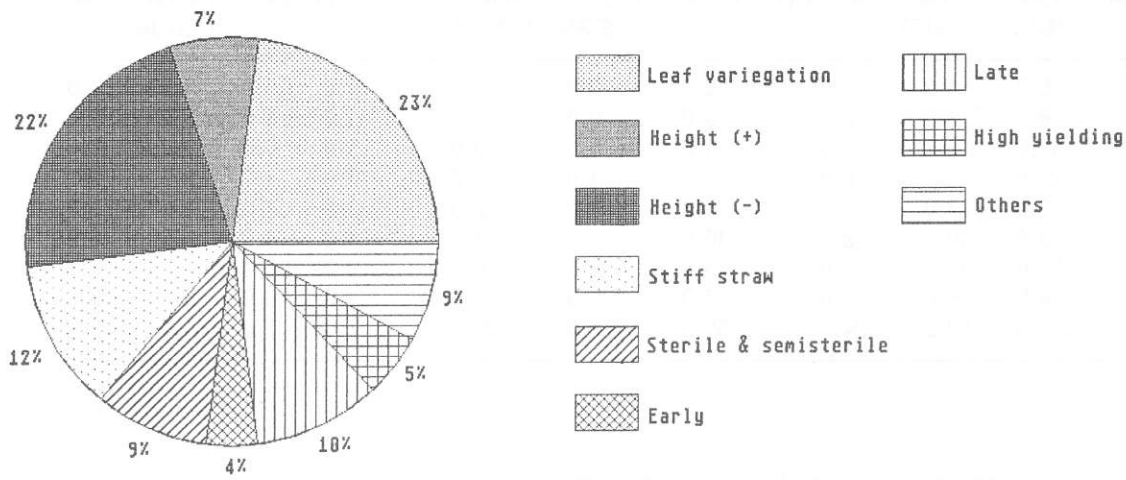

Table 5: Mutation spectrum in M_2 in *F. esculentum*.

DOSE RATE	TOTAL MUTANT	LEAF VARIEG.	HEIGHT(+)	HEIGHT(-)	STIFF STRAW	STERILE AND SEMI STERILE	EARLY	LATE	HIGH YIELDING	OTHERS
CONTROL	2.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
5 kR	5.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
10 kR	7.0	0.0	0.0	1.0	0.0	2.0	1.0	0.0	0.0	3.0
15 kR	7.0	0.0	0.0	0.0	2.0	0.0	1.0	0.0	0.0	4.0
20 kR	13.0	3.0	1.0	3.0	1.0	0.0	0.0	0.0	3.0	2.0
25 kR	27.0	5.0	2.0	4.0	2.0	1.0	2.0	5.0	2.0	4.0
30 kR	32.0	8.0	3.0	3.0	1.0	3.0	1.0	2.0	1.0	10.0
40 kR	51.0	11.0	0.0	12.0	4.0	5.0	2.0	7.0	0.0	10.0
TOTAL	144.0	27.0	8.0	22.0	11.0	9.0	8.0	17.0	6.0	36.0

Table 6: Mutation spectrum in M_2 in *F. tataricum*.

DOSE RATE	TOTAL MUTANT	LEAF VARIEG.	HEIGHT(+)	HEIGHT(-)	STIFF STRAW	STERILE AND SEMI STERILE	EARLY	LATE	HIGH YIELDING	OTHERS
CONTROL	7.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	4.0
5 kR	9.0	0.0	0.0	2.0	0.0	0.0	3.0	3.0	0.0	1.0
10 kR	11.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0	2.0	4.0
15 kR	21.0	4.0	2.0	3.0	2.0	1.0	3.0	2.0	2.0	2.0
20 kR	23.0	4.0	2.0	4.0	1.0	2.0	4.0	2.0	2.0	2.0
25 kR	29.0	6.0	3.0	8.0	3.0	2.0	0.0	3.0	2.0	2.0
30 kR	39.0	10.0	0.0	10.0	5.0	3.0	3.0	5.0	0.0	3.0
40 kR	61.0	14.0	0.0	16.0	8.0	5.0	5.0	10.0	0.0	3.0
TOTAL	200.0	39.0	9.0	43.0	20.0	13.0	20.0	26.0	9.0	21.0

Table 7: Mutation spectrum in M_3 in *F. esculentum*.

DOSE RATE	TOTAL MUTANT	LEAF VARIEG.	HEIGHT(+)	HEIGHT(-)	STIFF STRAW	STERILE AND SEMI STERILE	EARLY	LATE	HIGH YIELDING	OTHERS
CONTROL	5.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0
5 kR	9.0	1.0	3.0	0.0	0.0	0.0	1.0	1.0	3.0	0.0
10 kR	12.0	2.0	3.0	1.0	0.0	0.0	3.0	0.0	0.0	3.0
15 kR	25.0	5.0	6.0	4.0	1.0	0.0	3.0	1.0	3.0	2.0
20 kR	32.0	7.0	5.0	8.0	2.0	2.0	3.0	1.0	4.0	0.0
25 kR	38.0	10.0	2.0	10.0	0.0	3.0	4.0	4.0	0.0	5.0
30 kR	52.0	13.0	2.0	15.0	8.0	8.0	0.0	4.0	0.0	2.0
40 kR	78.0	18.0	2.0	17.0	10.0	10.0	2.0	6.0	0.0	13.0
TOTAL	251.0	57.0	24.0	55.0	21.0	23.0	17.0	17.0	11.0	26.0

Table 8: Mutation spectrum in M_3 in *F. tataricum*.

DOSE RATE	TOTAL MUTANT	LEAF VARIEG.	HEIGHT(+)	HEIGHT(-)	STIFF STRAW	STERILE AND SEMI STERILE	EARLY	LATE	HIGH YIELDING	OTHERS
CONTROL	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0
5 kR	11.0	1.0	3.0	1.0	0.0	0.0	0.0	1.0	1.0	3.0
10 kR	19.0	4.0	3.0	3.0	1.0	0.0	2.0	0.0	3.0	3.0
15 kR	31.0	7.0	5.0	0.0	3.0	1.0	3.0	1.0	5.0	6.0
20 kR	36.0	9.0	5.0	5.0	3.0	2.0	5.0	3.0	2.0	2.0
25 kR	37.0	9.0	3.0	5.0	5.0	4.0	0.0	4.0	2.0	5.0
30 kR	52.0	10.0	0.0	15.0	8.0	7.0	0.0	8.0	0.0	4.0
40 kR	103.0	26.0	0.0	35.0	15.0	12.0	0.0	12.0	0.0	3.0
TOTAL	290.0	66.0	19.0	64.0	35.0	26.0	11.0	29.0	14.0	26.0

Description of a few selected mutants:

Three mutants in *F. esculentum* and two in *F. tataricum* were selected.

I. Selection in *F. esculentum*:

1. High yielding mutant with condensed axis: This plant was isolated in M_2 generation of *F. esculentum* at 15 kR. Morphological characters of plant have been described in Table 9 for both M_2 and M_3.
2. An early, dwarf mutant with high branching and condensed axis was selected at 25 kR in M_2 generation. The morphological data for M_2 and M_3 generations have been presented in Table 9.
3. This high yielding tall mutant was selected at 20 kR. The morphology of the mutant has been given in Table 9.

II. Selection in *F. tataricum*:

1. Dwarf plant with very high yield and condensed axis was selected at 15 kR dose in M_2. Morphological data of the mutant have been given in Table 10.
2. A tall and early plant with high yield and much longer than normal branches was selected at a dose of 20 kR in M_2.

Table 9: Growth and yield attributes of some mutants of *F. esculentum*.

S.No.	Character	Mutant (1) M_2	Mutant (1) M_3	Mutant (2) M_2	Mutant (2) M_3	Mutant (3) M_2	Mutant (3) M_3
1.	Plant height (cm)	43.0	45.5	41.0	44.0	67.0	73.0
2.	Leaf area/plant (cm^2)	230.0	247.0	217.0	232.0	272.0	300.0
3.	No. of branches (primary)	3.0	4.0	5.0	5.0	6.0	8.0
4.	No. of nodes	8.0	9.0	9.0	10.0	12.0	12.0
5.	Days to bud initiation	32.0	33.0	28.0	30.0	29.0	33.0
6.	No. of inflorescences	29.0	34.0	23.0	22.0	32.0	36.0
7.	Pollen fertility (%)	90.0	93.0	89.0	90.0	89.0	92.0
8.	Yield per plant (g)	12.5	14.0	10.2	11.0	14.0	16.5
9.	Plant dry weight (g)	19.0	21.0	19.5	23.0	27.0	31.0
10.	Crude seed protein content (g/100 g flour)	12.1	12.8	11.3	11.7	12.0	12.5
11.	Fat content (g/100 g flour)	3.5	3.4	3.1	3.4	3.5	3.5
12.	Total carbohydrates (%)	63.8	64.5	61.0	62.3	65.1	65.6

Table 10: Growth and yield attributes of some mutants of *F. tataricum*

S.No.	Character	Mutant (1) M_2	Mutant (1) M_3	Mutant (2) M_2	Mutant (2) M_3
1.	Plant height (cm)	20.0	23.5	31.5	33.5
2.	Leaf area/plant (cm^2)	311.0	332.0	387.0	410.0
3.	No. of branches (primary)	4.0	5.0	6.0	6.0
4.	No. of nodes	10.0	12.0	14.0	17.0
5.	Days to bud initiation	36.0	33.0	28.0	27.0
6.	No. of inflorescences	42.0	47.0	52.0	58.0
7.	Pollen fertility (%)	92.0	91.0	90.0	93.0
8.	Yield per plant (g)	14.0	17.0	19.2	21.5
9.	Plant dry weight (g)	16.5	17.5	24.5	26.0
10.	Crude seed protein content (g/100 g flour)	10.7	11.2	10.9	11.5
11.	Fat content (g/100 g flour)	3.0	3.2	3.2	3.5
12.	Total carbohydrates (%)	67.2	68.0	67.0	69.5

The fact that cytological examination revealed a nearly normal meiosis with no or very little chromosomal aberrations in all the mutants examined suggests that meiotic irregularities in the form of chromosomal disturbances were not the cause of mutation. Mutations at the gene level seems to be the cause of appearance of mutations.

The recent significant contribution of mutation breeding for the crop improvement has not only resulted in the increased number of induced mutant varieties but also in their better quality and high yield performances (Sigurbjörnsson and Micke, 1969). Earlier it was felt that the main contribution through induced mutation would be to increase variability and to create new characters. It may be added that the most significant utilization of mutation breeding should be to confer specific improvement on a variety without altering its other morphological characteristics (Varughese and Swaminathan, 1967). This type of application promises to be of considerable importance in the drive to produce high yielding yet locally adaptable varieties.

References

Bhatia, C. and Swaminathan, M.S. 1963. Frequency and spectrum of mutations induced by radiations in some varieties of bread wheat. Euphytica 12: 97-112.

Chun, E.H.L., Vaughn, M.H. and Rich, A. 1963. The isolation and characterization of DNA associated with chloroplast preparation. J. Mol. Biol. 7: 130-141.

D'Amato, F., Scarasia, G.T., Monti, L.M. and Brozzini, A. 1962. Types and frequency of chlorophyll mutations in Durum wheat induced by radiations and chemicals. Rad. Bot. 2: 217-239.

Gaul, H. 1964. Mutations in plant breeding. Rad. Bot. 4: 155-232.

Gustaffson, A. 1940. The mutation system of the chlorophyll apparatus. Lund. Univ. Arsakr. N.R. 36 (2): 1-40.

Kurganova, L.N., Shigarova, T.Yu. and Viktorova, O.L. 1982. Effects of gamma irradiations on photosynthesis and transport of assimilates from mesophyll cells into the free space of leaf. Fd. Crop. Abs. 35 (11).

Ramanna, M.S. and Natarajan, A.T. 1965. Studies on relative mutagenic efficiency of alkylating agents under different conditions of treatments. Ind. J. Genet. 25: 24-26.

Ramulu, K.S. 1970. Induced chlorophyll chimeras and mutations in Sorghum. Madras Agric. J. 57: 727-732.

Roik, N.V. and Alekseeva, E.S. 1984. Chlorophyll mutations in buckwheat, their frequency and range. Pl. Br. Abs. 54 (2-3).

Sen, I.A. 1979. Speciality of the effect of chemical mutagen on several barley varieties. Soviet Genetics 15: 301-306.

Sigurbjörnsson, B. and Micke, A. 1969. Progress in mutation breeding. Induced mutations in Plants. IAEA: 673-698.

Varughese, G., and Swaminathan, M.S. 1967. Sharbati Sonora, a symbol of the age of algeny. Indian Farming 17 (5): 8-9.

RAZISKAVE MUTACIJ PRI AJDI (*FAGOPYRUM*)
II. VPLIV GAMA ŽARKOV NA KLOROFILNE IN DRUGE MUTACIJE

Izvleček

Ugotavljana je bila pogostnost klorofilnih mutacij pri navadni in pri tatarski ajdi. Najpogostejša mutacija je bila "maculata" (pegasta), najredkejša pa "albina" (bela). Pri tatarski ajdi je bilo več mutacij kot pri navadni. Glede na rezultate v M2 in M3 generacijah je pri obeh vrstah največ mutacij nastalo pri odmerku sevanja 40 kR. Višina rastlin (tako višje kot nižje rastline) in zatem črtavost listov sta bili najpogostejši mutaciji. Malo je bilo mutacij, ki bi vplivale na višino pridelka. Pet mutacij, tri pri navadni ajdi in dve pri tatarski ajdi, je bilo obetavnih.

Fagopyrum 9 (1989): 23-26

The morphology of buckwheat flowers depending on the course of plant flowering

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Key words: flowering, heterostyly, trait variation

Abstract

The relationship between development of buckwheat flower traits connected with heterostyly and flower opening sequence in the raceme and the stage of flowering phase was studied.

The significant influence of the investigated factors on formation of flower elements was found.

Introduction

A great number of flowers which are developing on the buckwheat plant in relation to rather small photosynthetic area of leaves and weak root system of this plant causes that water and nutrients supplying of flowers appears to be insufficient.

The undernutrition is likely to be a reason of disturbances observed during formation and development of some part of generative organs. Together with self-incompatibility and climatic conditions it could be a significant factor limiting buckwheat yielding (Adachi 1982; Pundrić and Kreft 1982).

As the duration of flowering period is long and flower opening in the raceme is irregular, the undernutrition might be observed in individual flowers in the raceme, as well as during different phases of flowering stage. The recognition of these interdependences is very important in the case of controlled crossing. Obtaining comparable results could be highly dependent on proper choosing of the flowers for crossing.

The aim of the research work done in the Department of Plant Breeding and Seed Production in the Agricultural and Technological University in Olsztyn was to establish interdependence between sequence of flower opening in the raceme and also the stage of flowering period and development of some morphological organs of flowers of buckwheat cv. Hruszowska.

Material and methods

Experimental materials were flowers of buckwheat cv. Hruszowska obtained from the seeds of elite degree in the field conditions. During 24 days flowers were collected from randomly chosen plants and racemes just after opening. During samples collecting the sequence of flowering was taken into consideration (from the first to the tenth flower) and also the stage of flowering period (I - beginning, II - full, III - the end of flowering).

The freshly collected buckwheat flowers were fixed in the Carnoy's fixative (for 1h) and stored in 70% ethanol in refrigerator. Staining or any other method for preparing flowers to microscopic study were not used.

In each flower the following were measured: the pistil length (from the base to the end of the longest stigma), the length of each stamen filament and diameters of 50 stigma cells and 50 pollen grains. The total number of measurements is given in the Table 1.

The obtained crude results were recalculated to μm and after compilation and counting of respective means variation analysis was carried out. For the estimation of the effect of flowering sequence the method of contrast was used by comparing respective values obtained for the first three flowers in the raceme with the data for the other flowers under consideration.

Table 1. The values of F function obtained from analysis of variation for morphological traits of flowers of Hruszowska buckwheat

Source of variation	Degrees of freedom	F empirical value			
		Pistil length	Filament length	Stigma cell size	Pollen grains size
1. Flower kind	1	2363.25**	3240.29**	182.43**	837.60**
2. Flower opening sequence in the raceme including:	9	7.78**	2.74**	4.00**	2.28*
3. from I - III to IV - X	1	46.17**	4.83*	27.92**	6.89**
4. Interaction	9	0.68	1.39	1.84	1.34
5. Error	180				
Total number of measurements		100	785	4620	4830
1' Flower kind	1	1993.30**	3257.90**	194.59**	278.58**
2' Stage of flowering	2	9.81**	3.11*	30.15**	35.09**
3' Interaction	2	4.78**	1.17	5.51**	18.96**
4' Error	174				
Total number of measurements		180	1388	5448	6493

* - significant at P = 0.05; ** - significant at P = 0.01.

Results and discussion

The analysis of obtained results showed close correlation between the flower size and opening sequence. The first three flowers in the raceme were bigger than other. This interdependence was statisticaly significant for all measured elements of flowers.

The general pattern of changes consisted in decrease of size of measured elements as succeeding flowers were opening. The course of this interdependence was very similar for both kinds of buckwheat flower and interaction between flower kinds and flowering sequence was not significant.

The distribution frequencies for all respective values of studied traits (elements of flower) were however differentiated (Fig. 1a - 1c). The pistil length was decreasing for both kinds of flower from the fourth in the raceme while decreasing of filament length was found only for seventh and eighth flower.

The size of stigma cells was distinctly smaller from the second flower opened in the raceme and this decrease was more visible for thrum than for pin flower. Mean values of this trait for the first three flowers in the raceme were significantly higher than respective means for the other flowers, however gradually decrease of pollen grain size was observed only in the ninth and the tenth flower. The size of pollen grains in the pin flowers showed other pattern of variation. For this flower kind the first three flowers formed markedly bigger pollen grains and in each succeeding opened flower this value was decreased.

The phase of flowering period also significantly differentiated the flower size. The largest sizes were found for flowers opened at the beginning of flowering and the smallest when they were sampled in the last week of flowering. The patterns of these changes were different for

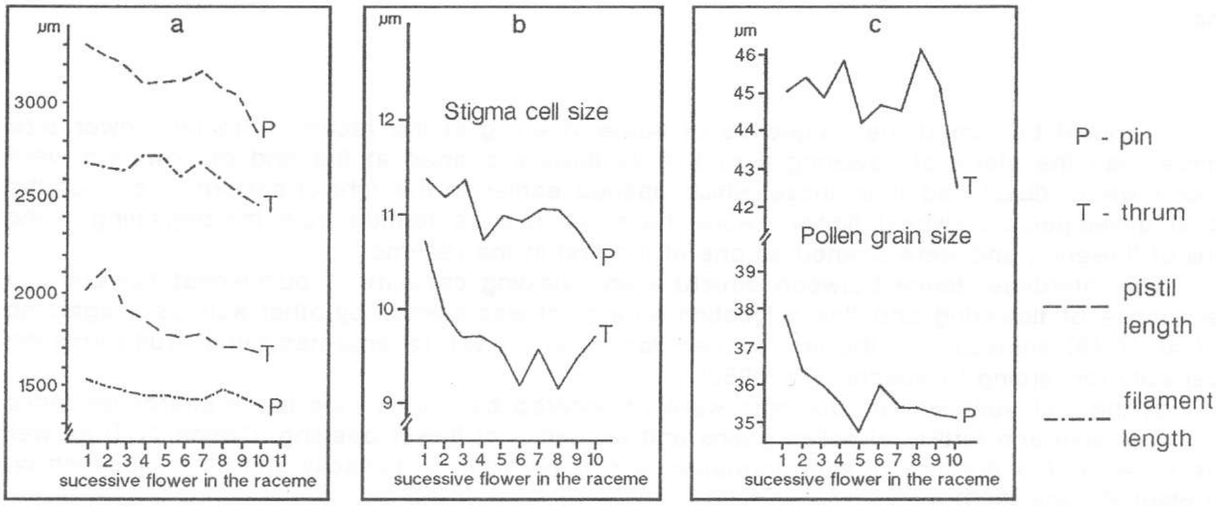

Fig. 1. The effect of flower opening sequence in the raceme on development of morphological traits of buckwheat flowers

two studied flower kinds of buckwheat (except filament length because for this trait the interaction between phase of flowering and kind of flower appeared not to be statistically significant). The intensity of changes was dependent on a given trait as well as on kind of flower. The pistil length for both kinds of flower was nearly the same from the beginning to the full of flowering. The decrease of the value of this trait was found only at the end of flowering and this decrease was much bigger for thrum flowers. Changes of the filament length were small and had a similar pattern for both kinds of flowers (Fig. 2a). Another type of this interdependence was found when sizes of stigma cells were studied. Flowers sampled at the beginning of flowering (both pin and thrum) had the largest stigma cells and distinct decrease of their sizes was found at the full of flowering and further decrease of this value succeeded later, but it was more pronounced for thrum flowers (Fig. 2b). Diameters of pollen grains originated from pin flowers were similar at the beginning or at full of flowering. The decrease of pollen grains sizes was found for pollen sampled at the end of flowering whereas for thrum flowers the largest pollen grains were found at the full of flowering period (Fig. 2c).

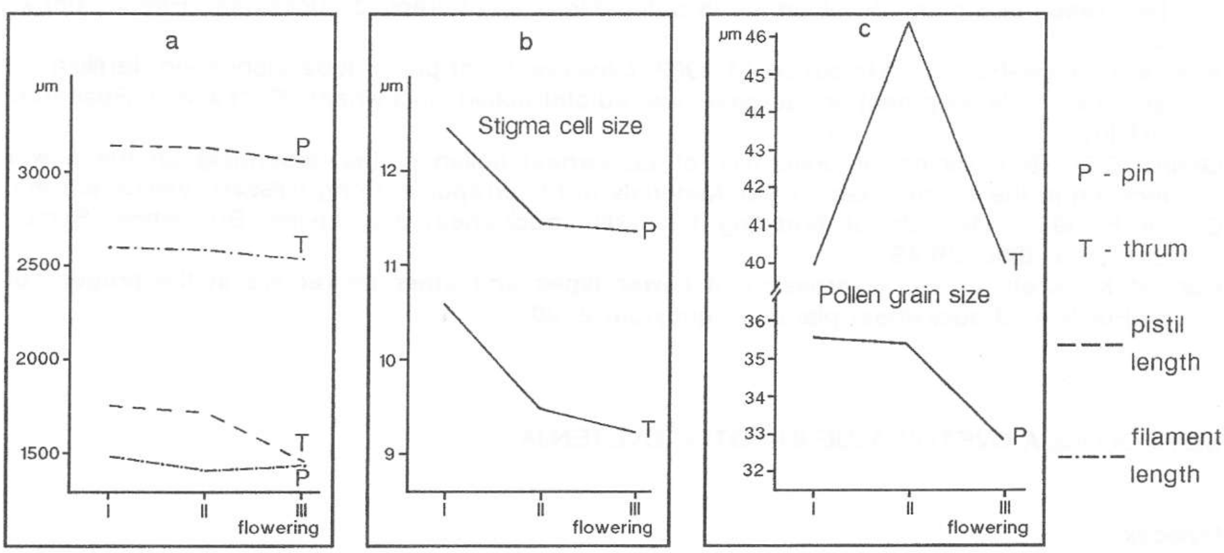

Fig. 2. The effect of the stage of flowering period on development of morfological traits of buckwheat flowers

It should be stated that sequence of flower opening in the raceme effected flower size more than the stage of flowering period. Only flowers opened at the end of flowering were much worse developed than those which opened earlier. In the light of performed studies the best developed buckwheat flowers were those which were formed from the beginning to the full of flowering and were opened as one of the first in the raceme.

The interdependence between structure and yielding capacity of buckwheat flowers and sequence of flowering and flower location on a plant was studied by other authors. Nagatomo *et al.* (1949) showed that the first opened flowers in a given raceme had better fruit formation capacity (according to Adachi *et al.* 1983).

In the last year similar problems were considered by Gorina. She found interdependence between size and fertility of pollen grains and sequence of flower opening (Gorina 1971) as well as between the duration of seed formation and its germination capacity and flower location on a plant (Gorina 1980).

The results presented in this paper confirm the opinion that buckwheat flowers have differentiated value (because not all flowers are capable of forming properly developed fruits) and flower selection for crossing, or for any other genetic-breeding research work could have a significant effect on yield quantity of seed material which could be used in further study.

Conclusions

1. The development of buckwheat flowers depends on the sequence of the flower opening in the raceme as well as on the stage of flowering period.
2. The largest sizes of all studied morphological elements of flowers originating from the beginning to the full flowering, when they were opened as the first, second or third in the raceme.
3. Thrum flowers developed at the end of flowering were characterized by more rapid decrease of values of studied traits in comparison with pin flowers of buckwheat.

References

Adachi T., Kawabata T., Yabuya T., Nagatomo T. 1982. Observation of pollen tube elongation, fertilization and ovule development in autogamous autotetraploid buckwheat. Fagopyrum 2: 5-7.

Adachi T., Kawabata T., Matsuzaki M. 1983. Observation of pollen tube elongation, fertilization and ovule development in autogamous autotetraploid buckwheat. Buckwheat Research: 103-107.

Gorina E.D. 1971. Biological uniformity of buckwheat pollen grains depending on the flower location in the raceme. Gen. i Sel. Materials of I Interrepublic Cong. (USSR), Vilnius: 182-183.

Gorina E. 1980. Methods of breeding for fertile buckwheat populations. Buckwheat Symp., Ljubljana, 1980: 39-49.

Pundrić K., Kreft I. 1982. Expression of flower types and other characters in the progeny of self-pollinated buckwheat plants. Fagopyrum 2: 20.

MORFOLOGIJA CVETOV AJDE IN POTEK CVETENJA

Izvleček

Avtorice so raziskovale razvoj cvetov ajde, lastnosti povezane s heterostilijo, zaporedje odpiranja cvetov v socvetju in stopnje cvetenja.

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The variation of traits related to heterostyly of buckwheat (*Fagopyrum esculentum* Moench) flowers

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Key words: flowering, heterostyly, trait variation

Abstract

The variation of traits connected with heterostyly of buckwheat flowers was studied. Range of variation, modal value for each individual trait were obtained and their respective distribution frequencies were presented.

Introduction

According to Adachi *et al.* (1982) heterostyly together with sporophytic incompatibility is one of the main reasons of low buckwheat fertility. The expression of traits connected with heterostyly is genetically determined (Kovalenko *et al.* 1980), however the structure of some flower elements could be modified by environmental conditions (Alekseeva 1967).

The performing of genetical - breeding works which are aimed at obtaining new self-compatible buckwheat forms by mutagenesis or by selection demands detailed definition of some traits of the initial plant material in specific environmental conditions.

The aim of presented work conducted in Department of Plant Breeding and Seed Production in Agricultural and Technological University in Olsztyn was to establish the variation range and calculation of standard values of morphological elements of long-styled (pin) and short-styled (thrum) flowers collected from buckwheat plants cv. Hruszowska cultivated in the conditions of north-eastern part of Poland.

Material and methods

The experimental material were the buckwheat plants cv. Hruszowska growing in the experimental field from seeds of elite degree.

Flowers were collected in the morning just after opening during the whole flowering period. Five flower from each randomly chosen plant were sampled. Then they were immediately fixed in Carnoy's fixative (for 1h) and stored in refrigerator in 70% ethanol at 5 centigrade. Staining or any other method was not used before observation.

The pistil length (from its base to the end of the longest stigma), length of filaments of each stamen and diameters of 50 stigma cells and pollen grains were measured in each studied flower. 206 thrum and 213 pin flowers were worked out. Total numbers of measurements of investigated traits are given in the Tab. 1. The obtained crude results were recalculated to μm and tabulated, and after then the results were divided into intervals and analyzed traits were characterized by basic statistical measures and graphically presented as respective distributions.

Results and discussion

The analysis of our results showed that the level of differentiation of an individual trait related to heterostylar structure of buckwheat flower is dependent on the kind of flower.

The pistil and filament lengths of thrum and pin flowers formed separate ranges of variation (Figs. 1a and 1b) whereas the sizes of stigma cells and pollen grains were more approximated and variation ranges of these traits were partly covered and gave a common area (Figs. 1c and 1d).

Table 1. The basic statistical measures of studied traits of cv. Hruszowska buckwheat flowers.

Item	Pistil length		Filament length		Pollen grain size		Stigma cell size	
	Thrum	Pin	Thrum	Pin	Thrum	Pin	Thrum	Pin
Arithmetic mean (µm)	1703.97	3056.59	2588.83	1441.96	42.61	34.92	9.63	11.52
Weighted mean (µm)	1707.74	3058.86	2591.08	1445.30	42.54	34.54	9.63	11.53
Modal value (µm)	1838.46	3146.15	2631.98	1382.90	43.04	35.49	9.57	11.41
Minimal value (µm)	891.34	2282.70	1717.46	869.60	19.35	17.98	3.36	5.50
Maximal value (µm)	2195.75	3734.70	3376.00	2004.50	63.86	58.05	16.46	23.74
Standard deviation (µm)	243.55	259.73	211.28	155.64	6.50	4.46	1.81	2.01
Variability coefficient (%)	14.26	8.49	8.15	10.77	15.28	12.91	18.75	17.50
Total number of measurements	206	213	1597	1623	5864	8501	6114	6316

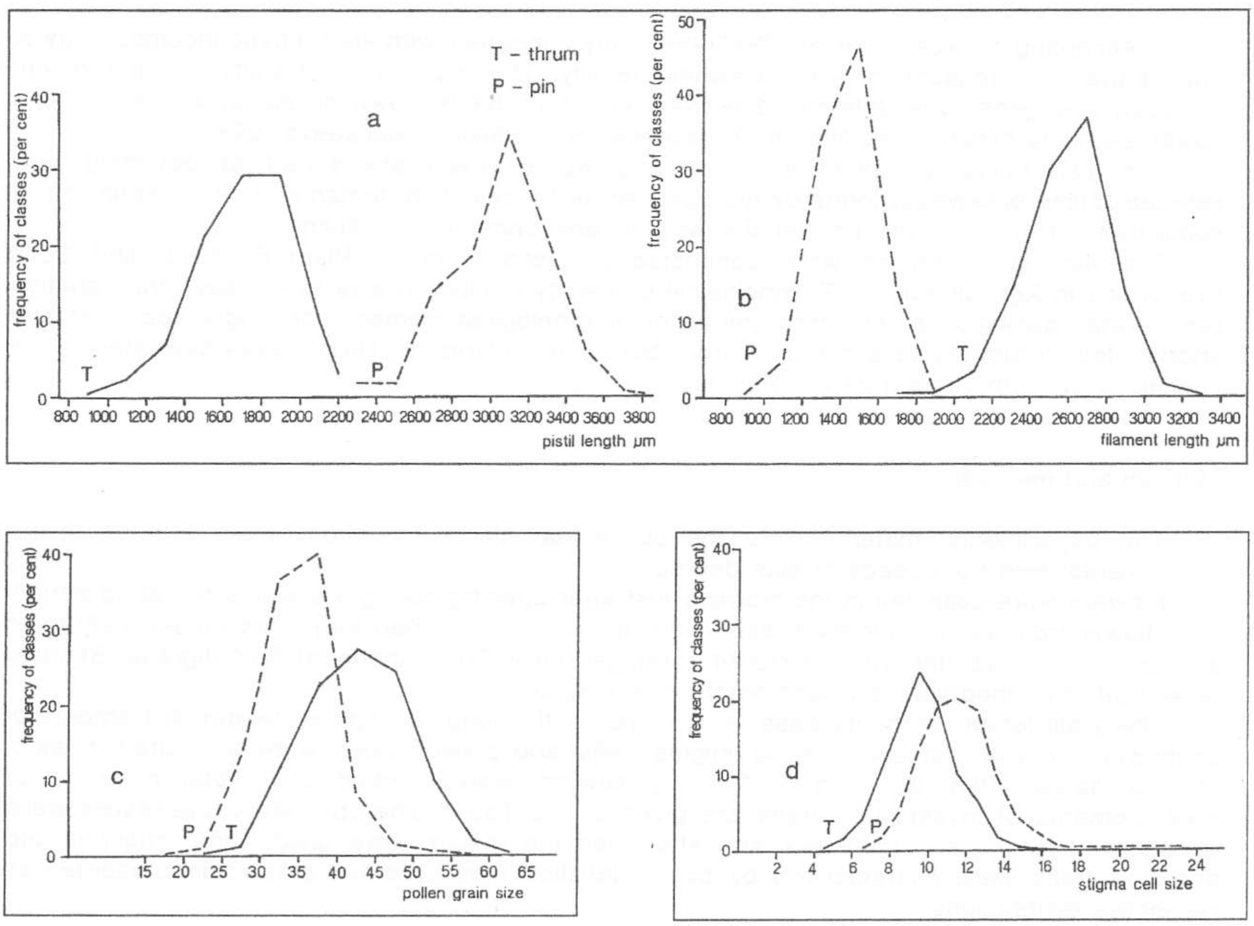

Fig. 1: The distribution frequency of studied traits in natural population of cv. Hruszowska buckwheat.

The length of thrum flower pistil ranged to a rather wide extent (from 800 to 2200 µm), however 93.2% of these pistils measured from 1300 to 2100 µm and this interval was recognized as typical for this kind of buckwheat flowers.

The most numerous group among the pin flowers (93.3%) were flowers of pistil length ranging from 2600 to 3500 µm. The modal values of this trait for two kinds of buckwheat flowers are showed in Tab. 1.

The length of stamen filament of typical thrum flower ranged from 2100 to 3000 µm and it was almost two times that of pin flower (respectively, from 1100 to 1800 µm). The percentages of flowers whose filament length was beyond the ranges of variation mentioned above were relatively small (from 2.5 to 3.1).

The variation of two kinds of buckwheat flowers with respect to two other traits e.i.: sizes of stigma cells and pollen grains was much smaller, although modal values of these traits were distinctly different. Diameters of stigma cells measured in thrum flowers ranged from 7 to 13 µm for 90.1% of studied plants and this value in pin flowers ranged from 8 to 15 µm and 60% of both kind of flowers belonged to common area of variation (Fig. 1c). The variation of pollen grains size showed a similar pattern. In spite of a substantial difference between modal values (43.1 µm for thrum and 35.5 µm for pin flowers) 50% of both kinds of flowers formed pollen grains belonging to the common variation area.

However buckwheat is a typical cross-pollinating plant, it was found that other types of pollination (illegitimate and selfing) resulted in fertilization and normal fruit development (Pauseva *et al.* 1971, Kusiorska *et al.* 1986) and it could be related to the smaller extent of differentiation of both kinds of flower with respect to sizes of stigma cells and pollen grains. Variability coefficients obtained for all studied traits of thrum and pin flowers were relatively low and it showed that the expression of heterostyly was mainly dependent on plant genotype. Up to now the structure and action of genes determining buckwheat heterostyly has been the subject of detailed studies (Adachi *et al.* 1980). Generally higher variation observed in the group of thrum flowers could be related to their heterozygosity.

It should be pointed out that for each studied trait basic statistical measures (arithmetic mean, weighed mean and modal value) were very close and distribution frequencies of those traits were symmetrical and therefore it could be concluded that population of Hruszowska buckwheat is established and genetically equilibrated.

Also it should be mentioned that selection conducted towards forms characterized by changes in flower structure could result not only in changes of variation range for individual trait, but also in a different shape of variation curve.

In the light of the results presented herein pistil and filament lengths should be recognized the main diagnostic traits because their variation ranges were distinctly different and well defined. The other traits (sizes of stigma cells and pollen grains) could be recognized as additional selection indicies and as it was mentioned above their measurements needed much manual work.

Conclusions

1. The level of differentiation of variation ranges of the morphological traits related to buckwheat heterostyly are to a great extent dependent on the kind of studied trait.
2. The pattern of variation of studied flower elements showed that they were formed on genetic background and environmental conditions had a minor value.
3. The variation ranges and modal values obtained for an individual trait could be recognized as typical for Hruszowska buckwheat and treated as comparative values in genetic and breeding studies.
4. The frequencies distributions of studied traits showed remarkable homeostasis level in natural population of Hruszowska buckwheat.

References

Adachi T., Yabuya T., Nagatomo T. 1980. Inheritance of stylar morphology and overcoming self-incompatibility in the progenies of induced autotetraploid buckwheat. Buckwheat Symp. Ljubljana, September 1-3, 1980: 17-28.

Adachi T., Kawabata T., Yabuya T., Nagatomo T. 1982. Observation of pollen tube elongation, fertilization and ovule development in autogamus autotetraploid buckwheat. Fagopyrum 2: 5-6.

Alekseeva E.S. 1967. K voprosu o geterostylii grecichi. Sel. i Sem. No. 7: 127-135.

Kovalenko V.J., Laptev A.V., Shumniy V.K. 1980. Genetic and breeding aspects of the reproduction systems in insect-pollinated species. I. Features of the heteromorphic reproductive systems in *Fagopyrum esculentum* Moench and possibilities of its transformation on the basis of homostyly. Genetics (USSR) XVI, 8: 1459-1465.

Kusiorska K., Adamkiewicz E., Samborska-Ciania A. 1986. Research works of a fructifing process of *Fagopyrum esculentum* depending on the type of flower pollination. Buckwheat Research, 1986, Part I: 155-161.

Pauseva Z.P., Vinnickaja D.U., Gorina E. 1971. Izucenije antigennych swoistw grecichi ot raznych tipow opylenia. Doklady T.S.CH.A. 168: 114-119.

VARIIRANJE LASTNOSTI HETEROSTILIJE CVETOV AJDE

Izvleček

Proučevane so lastnosti, povezane s heterostilijo cvetov ajde. Raziskava je pokazala, da je variiranje proučevanih lastnosti cvetov ajde odvisno predvsem od dednosti in manj od razmer v okolju. V proučevani ajdi Hruszowska je ugotovljen visok nivo homeostaze za proučevane lastnosti.

Fagopyrum 9 (1989): 31-40

Buckwheat diseases

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Key words: buckwheat, bacterial diseases, fungus diseases, virus diseases.

Introduction

It is very important to study buckwheat diseases in order to gain a more reliable yield. Buckwheat can be attacked by thirty kinds of fungi belonging to twenty-two different genera (Hohrjakova 1969). In terms of frequency and severity of diseases, viruses come afterwards. Eighteen kinds of viruses causing buckwheat disease are already known (Klinkowski 1968). Bacteria and mycoplasmas are not so numerous. We know much less about them. We are not aware of the literature systematically treating all the buckwheat diseases, or of detailed data on buckwheat diseases. Sometimes the agents of diseases are merely mentioned; descriptions are far from comprehensive.

We began to study buckwheat diseases a few years ago. In co-operation with geneticists and breeders we found some diseases not previously known in Yugoslavia, or some new places being infected by already known agents. Fungus diseases are our prime concern, while virus and bacterial disease agents have not been found here yet. Fungi can affect buckwheat all the time from its emergence till harvest, foliage being most infected.

The diseases found in Yugoslavia are discussed first, followed by those found in some other parts of the world. The article treats the location of different kinds of parasites, their biology, disease symptoms and measures of protection against some of them.

Fungus diseases

Fungi are the most frequent agents of buckwheat diseases worldwide. Our findings indicate that this holds true for our climatic conditions. Soil parasites cause the decay of germinating seed, dumping-off of seedlings, root and stem rot. Some of diseases attack foliage and inflorescence, the others infect only leaves or stems and form characteristic mycelium coverings. Some kinds of fungi cause leaf spots of different shape and colour. Infected leaves die and drop off.

Peronospora fagopyri Elen.

The disease was first found in Bretagne (France). Ducomet (1910) described the morphological properties of its agent and disease symptoms; but he did not identify it. In 1922, this fungus was examined by Elenev (Sidorova 1965), and named *Peronospora fagopyri.* In 1929, the fungus was found in Poland by Siemaszko, and named *Peronospora ducometi* Siemaszko et Jankovska (Siemaszko did not know Elenev's work). In 1934, Siemaszko mentioned that *Peronospora ducometi* was a synonym for *Peronospora fagopyri* Elen. The disease was later found also in some other countries. In 1934, the fungus was described in Japan by Tanaka (Kochman, Majewski 1970), and in Rumania by Savulescu (1948). Jankowska (1929) and Studzinska (1968) from Poland also reported on this disease (Zimmer 1978).

In 1977, it was found on research plots and commercial buckwheat fields in Manitoba (Canada) by Zimmer.

Lindtner (1957) did not find the disease in Yugoslavia, but he urged phytopathologists to give attention to the possibility of emergence of this pathogen in northwestern parts of Yugoslavia, especially in Slovenia.

In the same year, (1957) Janežič found this fungus in Dravsko polje and listed it in "Indeks rastlinskih bolezni v Sloveniji" (Index of plant diseases in Slovenia).

In the beginning of this decade, it was singularly found in northeastern parts of Slovenia. In 1987 and 1988, it was found on experimental plots near Ljubljana.

The fungus is described in French literature by Férault (1984), in Russian by Duvinevich (1961), Sidorova (1963, 1965), Hohrjakova (1969), Jakimenko (1982), Elagin (1984) and Peluiko (1987). According to the statements of Peluiko, the disease is much spread in the Soviet Union.

Referring to the last information (Mannandhar 1988), the pathogen is the most serious agent of buckwheat diseases in Nepal.

The leaves roll during the day. Chlorotic spots can be seen on upper sides of leaves. A greyish covering at the bottom side of the infected leaves (fig. 1) can only be seen early in the morning; when it is cloudy or rainy, also during the day. In warm and sunny weather, the conidiophores and conidia, forming this covering, lay down in such a way, that it is not easy to observe them. The fungus affects the leaves of younger plants, so as of those in "boot" stage or flowering stage. At first, the foliage situated just above the ground is affected, later on, the disease spreads quickly upwards. It may spread all over the plant. Damaged leaves die and drop off. Internodes grow shorter because of the disease. The quantity of seed is reduced.

Fructification organs, conidiophores with their conidia, grow singularly or in smaller groups (two or three together) through stomata from the bottom side of the leave. Conidiophores are dichotomously branched out (fig. 2). They are 400 μm high and have about 10 μm in diameter. They end on two dents, 5-10 μm long. Sidorova (1965) states morphological properties of the fungus, dependant on different growing areas of the Soviet Union. The conidiophores found on the buckwheat cultivated in the region of Kursk were 322-370 μm long and 9.3 μm wide; but in the region of Orel they were 232-403 μm long and 12.4 μm wide.

On conidiophores, there are oval conidia, greyish in colour, about 25 μm long and 15 μm wide. The data referring to the size of conidia vary a lot. Sidorova (1965) says that they are 25 μm long and 14 μm wide. According to Zimmer (1978), their average length is 24 μm and breadth 15 μm.

The mycelium overwinters in dead parts of infected buckwheat. In these parts oospores are formed (Jakimenko 1982, Elagin 1984). Oospores cause the primary infection, the secondary being caused by conidia. The fungus can overspend winter in the seed, so it can be transferred by infected seed as well. It attacks *Fagopyrum esculentum* Moench and *Fagopyrum tataricum* (L.) Gärtn. Inoculation of some other plants of the same family (*Polygonum aviculare* L., *P. lapatifolium* L., *Rumex acetosa* L. and *Rumex acetosella* L.) by *Peronospora fagopyri* was not effective (Sidorova 1965).

One of limiting factors regarding the dissemination of this buckwheat disease is shortage of moisture. Elagin (1984) states that some cultivars are more often attacked than others. Peluiko (1987) says that early cultivars are more susceptible to the disease than late cultivars. Elagin (1984) ascertained the reduction of yield for 30%, Jakimenko (1982) for 20%. There is not much data on disease control. Our experience proved fungicide metalaxil to have good effects when applied in recommended doses as soon as the first symptoms of disease are detected.

Erysiphe polygony D.C.

The fungus parasitize 357 species of plants belonging to 157 different families (Viennot - Bourgin 1949). According to the statements of Kirchner (1923) and Jaczewsi (1927) (quoted by Blumer 1967), it does not frequently live on buckwheat. The fungus is mentioned in Japanese literature as well. Ferault (1984) says that the disease affects just its leaves and stems. The parasite spreads quickly in dry and warm weather. It infects *Polygonum* and *Rumex* species, too.

In Slovenia, it was found individually in the form of a powdery covering on the leaves of buckwheat (fig. 3) grown in agricultural experimental field of Biotechnical Faculty of Ljubljana. The covering was formed by conidiophores and oidia.

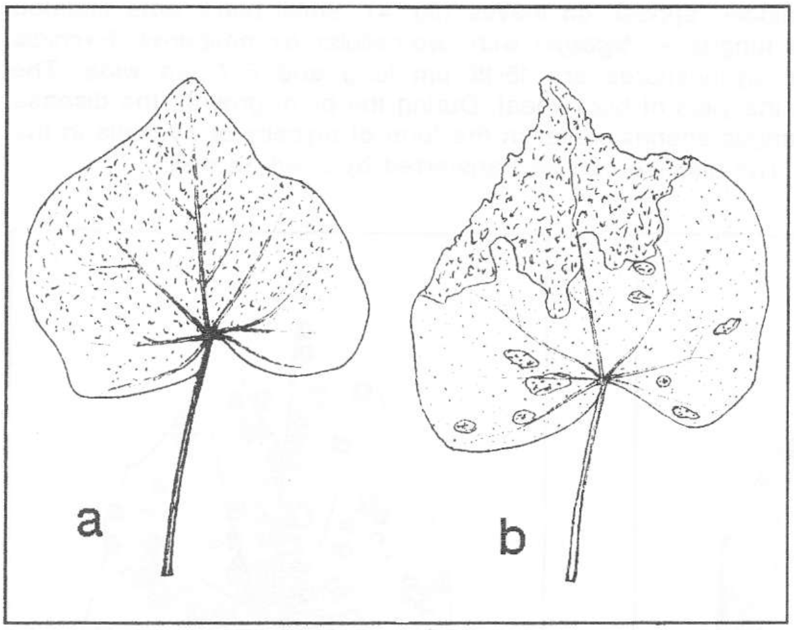

Fig. 1: Disease symptoms caused by *Peronospora fagopyri*
a) Characteristic covering
b) Characteristic covering, necrotic spots and death of a part

Sl. 1: Bolezenski znaki, ki jih povzroča gliva *Peronospora fagopyri*
a) Značilna prevleka
b) Značilna prevleka, nekrotične pege in odmrli del lista

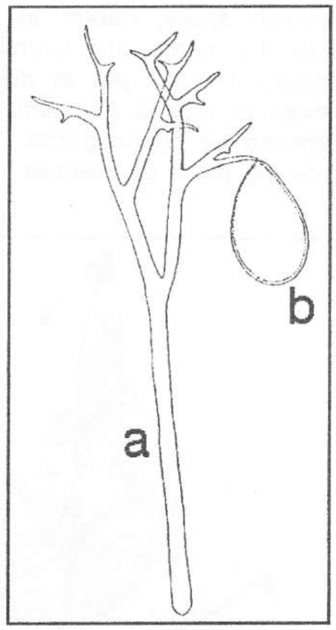

Fig. 2: Conidiophore (a) and conidium (b) of *Peronospora fagopyri*

Sl. 2: Trosonosec (a) in tros (b) glive *Peronospora fagopyri*

Ramularia spp.

This leaf spot disease is known in some countries but cases of serious damages are rare. It is studied by Sando (1956) in America, and by Elagin (1984) and Hohrjakova (1969) in the Soviet Union. Hohrjakova says that there are three species which parasitize buckwheat. These are: *Ramularia anomala* Pk. (= *R. rufomaculans* Pk.), *Ramularia curvula* Fautr. and *Ramularia fagopyri* Abrahmov. The first one is included in the index of host plants of North America by Seymour (1929). The disease is also listed in Japan research literature (Soba Syubyoo 1981).

These fungi are spread all over Yugoslavia (Janežič 1957). They infect the leaves of buckwheat at the time of flowering, especially when the weather is wet and warm. The spots of different size and assymetrical shape appear on leaves. Delicate coverings on bottom sides of leaves are limited into small spots by veins.

When the infection is strong, the whole bottom area of the leaf is covered. The covering is made by conidiophores which are in clusters. On conidiophores, there are cylindrical or spindle - like conidia. They are hyaline or bright yellowish. The infected leaves first get yellow, then they turn brown and after that they drop off. More and more plants are affected by conidia while growing. The fungus overwinters in the form of conidia or mycelia in the remaining parts of diseased plants.

Ascochyta fagopyri Bresad.

Spottiness of buckwheat caused by the fungus *Ascochyta fagopyri* Bresad. is reported by Russian researchers (Hohrjakova 1969, Jakimenko 1982, Elagin 1984) and others. It is dealt with by Lindau (1922), Seymour (1929), and Soba Syubyoo (1981). According to the statement of Janežič (1957), it is spread all over Yugoslavia. In 1982, it was also found on buckwheat grown in experimental fields of Biotechnical Faculty of Ljubljana. It affects leaves and stems.

Brownish spots, darker in the middle, appear on leaves (fig. 4). Small black dots situated inside the spots are pycnidia of fungus *A. fagopyri* with two-cellular pycnospores. Pycnidia measure 130-140 µm in diameter, pycnospores are 16-18 µm long and 6-7 µm wide. The disease causes 5-7% damage to the yield of buckwheat. During the plant growth, the disease is spread by pycnospores. The fungus spends winter in the form of mycelia or pycnidia in the remaining parts of infected plants. The disease can be transferred by seed as well.

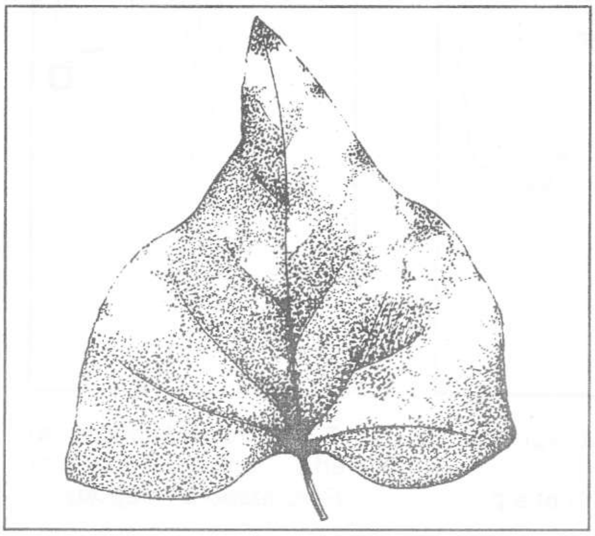

Fig. 3: Disease symptoms caused by *Erysiphe polygoni*

Sl. 3: Bolezenski znaki glive *Erysiphe polygoni* na listu

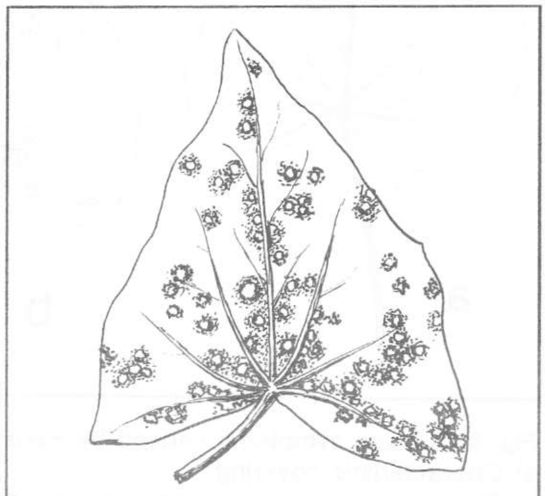

Fig. 4: Disease symptoms caused by *Ascochyta fagopyri*

Sl. 4: Bolezenski znaki, ki jih povzroča gliva *Ascochyta fagopyri*

Phyllosticta polygonarum Sacc.

This fungus disease affects the leaves of buckwheat. We do not know much about it. It is mentioned by Hohrjakova (1969) in the Soviet Union, by Soba Syubyoo (1981) in Japan, and by Seymour (1929) in America.

It was detected and determined in agricultural experimental field in the neighbourhood of Ljubljana (Yugoslavia) in 1982.

The symptoms of disease are bright brown spots with reddish margins. Their shape is assymetrical. There is a lot of dark dots on them, which are pycnidia. In pycnidia, there are one-cellular oval pycnidiospores. Their length is 4 µm, their breadth 2-2.5 µm. We do not have much information on the conditions for its spreading and on severity of damage it causes on buckwheat crop.

Sclerotium rolfsii Sacc.

The fungus was found on buckwheat called *F. sagittatum* in India (Karnataka) by Kulkarni, Siddaramaiah, Hegde and Hosmani (1978). The disease affected mainly the seedlings, also the germination was worse. The damage caused was up to 20%.

This fungus affects about 150 plant species of various genera (Maček 1983). It can be find in tropical and subtropical countries, also in some parts of Europe. It is a quarantine disease in Yugoslavia. Its favourite temperature is 25-30°C, and air humidity 80-90%. In the form of sclerotia, it remains in soil and in seed.

Among seed microflora, there are some other fungi on buckwheat in India (Singh, Sindhu, Singhal, 1984). Buckwheat seed is particularly affected by *Aspergillus fumigatus* Fres., *Curvullaria pallescens* Boedijn. and *Fusarium oxysporum* Schlecht.

The microflora of buckwheat seed was examined also by Mills and Wallace (1971) in Canada. So were the possibilities of fungicide usage for disinfection of seed. Among fungi, *Cladosporium* spp., *Cephalosporium* spp., *Streptomyces* spp., *Aspergillus candidus* Link. et Fr. and *Penicillium* spp. are mentioned.

Rhizoctonia spp., *Sclerotinia* spp., *Fusarium* spp., *Botrytis* spp., *Phytopthora* spp.

According to the statements of McKenzie, Duczek and Verma (1972) from Canada (Saskatchewan), root rot and stem base rot on buckwheat (fig. 5) is caused by fungi belonging to the following genera: *Rhizoctonia* spp., *Sclerotinia sclerotiorum* (Lib.) de By, *Fusarium* spp., *Botrytis* spp. The fungus of *Rhizoctonia* genus was isolated from roots, and *Fusarium* spp. *Sclerotinia sclerotiorum* from stems. These fungi were also proved some years later by Morall and McKenzie (1975). Hohrjakova (1969) found out that beside the above mentioned *Sclerotinia sclerotiorum* also *Sclerotinia fagopyri* Hory caused the stem rot.

Fusarium species causing the root rot are reported by Sidorova (1965). *Fusarium* spp. disease affects buckwheat mainly in wet season. The following fungi were isolated from diseased plants: *Fusarium heterosporium* Nees et Fr., *F. oxysporum* Schlecht et Fr. var. *orthoceras* (App. et Wr.) Bilai, *F. gibbosum* App. et Wr. var. *bullatum* Sherb Bilai. The fungi of the same species cause also tracheomycoses. *Fusarium* species usually develop on weak plants because of mechanical injuries, virus diseases and because of other reasons that diminish plant resistance.

Buckwheat rot is caused by fungus *Phytophthora cactorum* Lebert (Appel 1928) too. Beside this fungus, Hohrjakova mentions also the species *P. fagopyri* Takimoto, which causes the root and the stem rot.

Alternaria alternata (Fries) Kreis

This parasite was found on buckwheat (*Fagopyrum esculentum*) in Canada (Zimmer 1974), and on *Fagopyrum saggittatum* in India (Siddaramaiah, Kulkarni, Hosamani 1979). In the Soviet Union, Hohrjakova (1969) lists also another species named *A. fasciculata* C. et. E. Jones et Grant. It infects seeds, stems and leaves. *Alternaria* spp. on buckwheat is described by some other authors (Jakimenko 1982, Elagin 1984) as well.

The disease symptoms are chlorotic leaf spots, uniformly distributed or dispersed, having concentric margins. They are circular, oval or oblong in shape. Each spot has a greyish centre and a brownish margin. Many conidia are arranged on a conidiophore, they are multi-cellular, club-shaped, turned upside down (fig. 6). Siddaramaiah et al. (1978) report that the length of spores is 21-60 μm, and their breadth 8-19 μm. Mills and Wallace (1971, 1972) found *Alternaria* spp. also on buckwheat seed. They cause poor germination and damping off. In Canada, the fungus *A. alternata* was isolated from seed by Zimmer (1974).

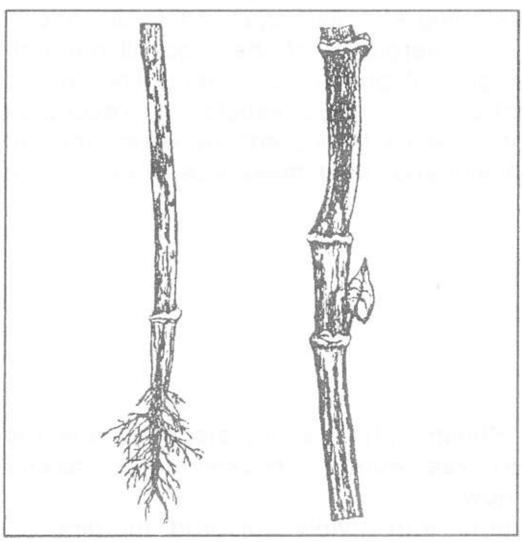

Fig. 5: Root and stem root
Sl. 5: Koreninska in stebelna gniloba

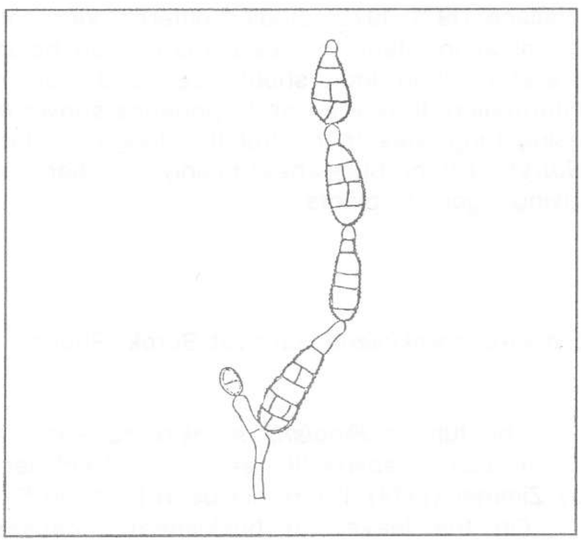

Fig. 6: Conidia of the fungus *Alternaria alternata*
Sl. 6: Konidiji glive *Alternaria alternata*

Botrytis cinerea Pers.

The perfect stage of fungus *Botrytis cinerea* is *Sclerotinia fuckeliana* (de Bary/Fuck). The fungus is widespread on numerous cultivated plants and weeds. It is a saprophyte and a facultative parasite.

It is one of economically important parasites attacking buckwheat in the Soviet Union (Sidorova 1965, Pak, Iodko 1971, Jakimenko 1982, Elagin 1984) and in Canada (Mills, Wallace 1971, 1972; Morrall, McKenzie 1972, 1975).

In Slovenia, it was found by Janežič (1957) in Ljubljana neighbourhood. The fungus infects buckwheat from germination till harvest. It causes dumping-off of seedlings (Mills, Wallace 1971, 1972). It also affects stems which rot. Morall and McKenzie (1975) found 14.5% of infected stems of buckwheat in Saskatchevan, here and there the leaves were infected, too. According to the statements of Jakimenko (1982), it affects mainly leaves, stems and inflorescence of buckwheat, the crop being reduced for 40-50%. According to the findings of Elagin (1984), the plants are more infected towards the end of flowering time. That causes 40-50% of loss. *Botrytis* rot is one of the most important diseases of buckwheat in the Soviet Union, which can reduce the crop from 1.5 to 2 times (Sidorova 1965). When it emerges in flowering time, the seeds are stunted and do not grow ripe.

Botrytis cinerea is one of the most widespread fungi on the world. Its conidia can be found everywhere. They are able to affect less resistant cultivars and those already injured by other kinds of parasites. Conidia germ in a drop of water, hyphae pass through undamaged epiderm and spread through the plant intracellularly. After some days, a grey surface occours, made of conidiophores and conidia. Conidiophores are branched out. One-cellular conidia are connected by short sterigmata, normally five, six or even more together. The sizes of conidiophores and conidia vary a lot and depend much on host plants. Sidorova (1965) examined this parasite in a pure culture, isolates were of different origins. Conidia in isolates from the area "Orlovskaja oblast" (Soviet Union) were 9.86 µm long and 8.15 µm wide on average. Conidia in isolates from Altaja were 11.03 µm long and 8.04 µm wide.

Fungus remains in soil in the form of sclerotia, which optimally form on soil surface up to 10 cm deep. Their formation is worse up to 20 cm underground. The fungus prospers in humid conditions, therefore it is much spread in wet soil. Elimination of infected plants, their ploughing under and mineralization are the three important ways of control. Sowing must not be too close, there must not be too many weeds, fertilization should be optimal. The resistance of cultivars against this disease has not been examined yet (Sidorova 1965). Elagin (1984) states that there are no cultivars resistant against this disease but some of them are more tolerant. Pak and Iodko (1971) mention thermotherapy as a kind of control. Two hours at 50°C reduced the infection of buckwheat from 16% to 8%. Yield was higher, too. Mills and Wallace (1971, 1972) studied different kinds of fungicides being effective against this disease in germination stage of seed. Plants can be infected from emergence of the crop till harvest; therefore fungicides should be used also in later stages of growth, but, according to our information, they are not. Experience shows that it is not possible to get satisfactory results by using fungicides to control this fungus. It looks to be necessary to prevent the emergence of *Botrytis* rot on buckwheat mainly by means of agrotechnical and other measures of prevention giving vigour to plants.

Bipolaris sorokiniana Sacc. et Sorok. Shoem.

The fungus *Bipolaris sorokiniana* Sacc. et Sorok. Shoem. (the perfect stage of which is *Cochliobulus sativus* (Ito et Kurib.) Drechsler et Dastur) was found on buckwheat of Canada by Zimmer (1974). It has not been found in Slovenia till now.

On the leaves of buckwheat it causes small spots with vividly coloured margins. In Canada, the disease appeared either at the beginning of flowering or later in the time of lush inflorescence. The fungus was isolated from seed, too.

Cercospora fagopyri Abramov., *Cercospora polygonacea* Ell. et Ev.

The disease is studied mainly by Russian authors (Hohrjakova 1969, Jakimenko 1982, Elagin 1984) The fungus is mentioned by Japanese literature (Soba Syubyoo 1981). From time to time, buckwheat in Nepal (Manandhar 1988) is affected by this disease, which is not very severe.

Its symptoms are leaf spots, round in shape (fig. 7). They measure to one cm in diameter, and are brighter in the centre. In these spots, conidiophores and multi-cellular conidia are formed.

The disease is getting worse during the growing period of plants. The first signs of damage can be seen before the time of flowering. Infection is strong in that time and later. Leaves are getting dry and the quantity of yield can be diminished up to 5% (Jakimenko 1982). The fungus spends winter in the form of mycelium or in the form of conidiophores and conidia on the remaining parts of diseased plants.

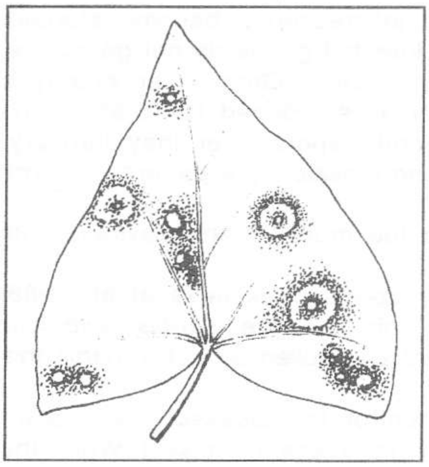

Fig. 7: Disease symptoms caused by *Cercospora* spp.

Sl. 7: Bolezenski znaki, ki jih povzroča gliva *Cercospora* spp.

Virus diseases

Viruses are an important kind of parasites. They may cause a great damage. On buckwheat, several viruses have been found (Férault 1980, 1984). The disease symptoms they cause are: bands along veins, chlorotic and necrotic spots, leaf deformations, dwarfing. Tobacco mosaic virus, cucumber mosaic virus, and fire blight virus are the three often examined kinds of viruses, which cause a considerable damage.

Tobacco mosaic virus

Tobacco mosaic virus infects numerous plants belonging to 120 different genera. On buckwheat, it was first found by Grant (1934). It was studied by Russian literature (Krotov 1969a,b) but it was not found on buckwheat in France (Férault 1984). It causes chlorotic spots and deformations of leaves which dry. The disease causes growth disturbances and diminishing of yield. Virus particles are transferred by juices and by mechanical contacts. According to Krotov (1969a), aphides do not transfer these viruses.

Cucumber mosaic virus

This virosis is discussed by Russian (Krotov 1969a,b), French (Férault 1980, 1984) and other literature. Buckwheat cultivation can be severely damaged by this kind of parasites. Such a virus has numerous hosts (over 300). It infects cucumbers, melons, peppers, tomatoes and weeds. The first symptoms of disease on buckwheat show a month after sowing and develop quickly. Discoloured areas appear among leaf veins which sometimes become brighter and deformed. Assymetrically distributed reddish mottles appear on the leaves of mature plants and turn dry. The injuries of lower leaves are greater than those of the leaves situated in upper etages. The youngest leaves look healthy. Affected plants are normally 20-30 cm smaller than healthy, vigorous ones.

The virus is transferred by aphids, not by seed. We should try harder to cultivate more resistant cultivars (Férault 1980).

Fire blight virus

It is much spread on buckwheat in the Soviet Union (Sidorova 1965, Hohrjakova 1969, Alekseeva, Ševčuk, Kološjan 1988). The first symptoms of disease show in the "boot" stage. The diseased plants are smaller, their development is stunted. Plants remain for 36-52% smaller than others. The disease was examined by a group of experts in the Soviet Union (Alekseeva *et al.* 1988).

Internodes are shorter, nodes get thicker, shoots and inflorescence become stunted. Infected inflorescence later turn dry. Flowering time is longer. Infected grains do not germinate. The seeds of affected plants are not suitable for further propagation. Germination energy is also reduced. The fertility of affected plants is usually lower. It is reduced to 75-85%. The symptoms of disease can be seen on leaves. They get necrotic spots, later they turn dry. Such plants look burned. Secondary shoots form. Clorotic and mosaic - like patterns emerge on leaves.

The virus causing fire blight on buckwheat belongs to the group of rhabdoviruses. Its properties are examined by Alekseeva *et al.* 1988.

According to Krotov (1969), fire blight is transmitted by aphids. Alekseeva et al. (1988) found seventeen different kinds of vectors transmitting this disease (*Aphis evonymi*, *Psamotettix striatus*, *Aphallara exillis*, *Cymnocerata* etc.). Seed and pollen do not transmit this virus which also cannot remain in dead plant parts.

The time and the way of sowing are important to control the disease. Early sown buckwheat was hardly affected. The infection of lately sown crops was increasing. When the seeds are sown too close, the crop is more affected. According to the statements of Soviet experts, the fire blight does not attack all the cultivars to the same degree. Alekseeva et al. (1988) quote seven cultivars being more or less resistant against this disease.

Krotov (1969b) deals also with other viruses, causing diseases of buckwheat. They are: *Ruga verrucosanas var. bresiliesis*, Dodder latent mosaic virus and Aster yellows virus. According to Klinkowski (1968), there are eighteen different viruses attacking buckwheat.

Bacterial diseases

Buckwheat diseases caused by bacteria are not numerous. Nevertheless, some of them affect this crop very seriously. There is not much information on this kind of diseases (Avezdzhanov, Avezdzhanova 1982).

Bacterium solanacearum (Smith) Smith is much spread over the world. It has already been found nearly on all the continents. Besides buckwheat it infects also other plants of *Polygonaceae*.

In the Soviet Union, there are three other kinds of bacteria affecting buckwheat (Avezdzhanov, Avezdzhanova 1982). Plants are infected in the "boot" stage and in the beginning of flowering time. *Bacterium proteamaculans* (Paine et Stansfield) Ell. causes reddish rimmed spots on leaves, usually connected on margins. *Xanthomonas heteroceae* (Wsorow) Savulescu causes yellowish rimmed spots on leaves. *Pseudomonas angulata* (Fromme et Murray) Holland causes assymetrical, necrotic spots with narrow, green margins. The central parts turn yellow first, then the tissue falls out. All the three kinds of bacteria are transferred by buckwheat seed. Avezdzhanov and Avezdzhanova (1982) examined twelve fungicides for disinfection of seed and proved TMTD to be the best.

Conclusion

The economic significance of buckwheat diseases in Yugoslavia and all over the world is closely connected with the quantity of buckwheat. The dissemination of single kinds of parasites depends on the sensitivity of cultivars, on climatic conditions and on agrotechnical measures (time of sowing, planting density, manuring, rotation of crops). Some special attention must be paid to parasites described although not found on buckwheat yet, but already attacking other host plants. Such parasites are: *Botrytis cinerea*, *Sclerotinia sclerotiorum*, *Rhizoctonia* and *Fusarium* spp., *Alternaria alternata*. Virus and bacterial diseases causing serious damage to the buckwheat cultivation should be carefully observed. Their control is based on optimization of growing conditions and on breeding of new, more resistant cultivars. In some cases, the disinfection of seed with fungicides or with thermotherapy is recommended. The data on the use of fungicides during the vegetation or on other ways of control are scarce.

References

Alekseeva E.S., Ševčuk V.K., Ševčuk T.E., Kalašjan J.A. 1988. Vredonosnost virusnogo ožogov grečihi i ishodnoii material dlja selekcii na ustoičivost k njema. Dokladi Vsesojuznoi akademii seljskohozjaistvenih nauk imeni V.I. Lenina 10: 4-6.

Appel O. 1928. Handbuch der Pflanzenkrankheiten. Die Pflanzliche Parasiten. Verlagsbuchhandlung Paul Parey, Berlin: 1-758.

Avezdzhanov R.M., Avezdzhanova G.P. 1982. Tipi bakterialnoi pjatnistosti grečihi. Bylleten Vsesoyuznogo Naučno-Issledovatel'skogo Instituta Rastenievodstva imeni N.I. Vavilova 124: 62-65

Blumer S. 1967. Echte Meltaupilze (Erysiphaceae). VEB Gustav Fischer Verlag Jena: 299.

Elagin I.N. 1984. Agrotehnika grečihi. Kolos, Moskva: 60-65.

Férault A.C. 1980. Le sarrasin et le virus de la Mosaïque du concombre. Phytoma 315: 13-14.

Férault A.C. 1984. Le sarrasin: une plante sans problèmes parasitaires. Phytoma 360: 18-19.

Grant T.Y. 1934. The host range and behaviour of the ordinary tobacco mosaic virus. Phytopathology 24: 311-336.

Hohrjakova M.K. 1969. Ukazatel vozbuditelei boleznei sel'skokhozjaistvenih rastenii. Leningrad: 46-48.

Jakimenko A.F. 1982. Grečiha. Kolos, Moskva: 165-169.

Janežič F. 1957. Indeks rastlinskih bolezni v Sloveniji. Zbornik za kmetijstvo in gozdarstvo, 3, FAGV, UL: 50.

Klinkowski M. 1968. Pflanzliche Virologie. Akademie Verlag Berlin. Bd. II, Teil 1: 1-457; Bd. II, Teil 2: 460.

Krotov A.S. 1969a. O virusnih boleznjah grečihi. Selskokhozjaistvena biologija 4 (5): 719-723.

Krotov A.S. 1969b. Virusnie bolezni grečihi. Trudi po prikladnoj botanike, genetike i selekcii 2: 247-254.

Kochman J., Majewski T. 1970. Grzyby (Mycota). Panstwowe wydawnictwo naukowe. Waršawa: 98-99.

Kulkarni S., Siddaramaiah A.L., Hegde R.K., Hosmani S.A. 1979. Two new root rot diseases of buck wheat in India. Indian phytopathology 32: 305.

Lindau, G. 1922. Die mikroskopischen Pilze. (Ustilagineen, Uredineen, Fungi imperfecti). Berlin, Verlag von Julius Springer: 1-301.

Lindtner V. 1957. Plamenjače. Građa za kriptogamsku floru Jugoslavije. Glasnik prirodnjačkog muzeja srpske zemlje. Serija B, Biološke nauke, knjiga 9: 124.

Maček J. 1983. Posebna fitopatologija - patologija poljščin. UEK Ljubljana, Biotehniška fakulteta: 1-286.

Manandhar J.B. 1988. Personal information.

Marshall H.G. et al. 1982. Buckwheat, Description breeding, production and utilization. Advances in Cereal Science and Technology, 5. St Paul, Minnesota: 194-210.

Mills J.T., Wallace H.A.H. 1971. Microflora of buckwheat seed, changes in storage and effect of seed treatments on seedling emergence. Can. Plant Dis. Surv. 51 (4): 154-158.

Mills J.T., Wallace H.A.H. 1972. Differential action of fungicides upon fungi occurring on wheat, barley, buckwheat, and oil seeds. Can. J. Plant. Sci. 52: 281-290.

Morrall R.A.A., McKenzie D.L., Duczek L.J., Verma P.R. 1972. A qualitative survey of diseases of some specialty crops in Saskatchewan in 1970 and 1971: sunflower, safflower, buckwheat, lentil, mustards, and field pea. Can. Plant Dis. Surv. 52: 143-148.

Morrall R.A.A., D.L. McKenzie. 1975. Diseases of specialty crops in Saskatchewan: 1. Notes on buckwheat and sunflower 1972-73. Can. Plant Dis. Surv. 55: 69-72.

Pak P.V., lodko I.I. 1971. Seraja gnil grečihi. Selekcija, genetika i biologija grečihi, Orel: 188-191.

Peluiko Z.I. 1987. Genetika, selekcija, semenovodstvo i vozdeljivanie krupjanih kultur (genetika, ris). Zbornik naučnih trudov, Kišinev: 93-97.

Sando W.J. 1956. Buckwheat culture. Farmers Bull. 2095, U.S. Dep. Agric.: 1-23.

Seymour A.B. 1929. Host index of the Fungi of North America. Cambridge Massachusetts Harvard University Press: 292.

Siddaramaiah A.L., Kulkarni S., Hosamani S.A. 1975. A new leafspot disease of buck wheat in India. Current Science 48 (7): 317.

Sidorova S.F. 1965. Izučenie naibolee vredonosnih boleznej grečihi. Vsesojuznaja ordena Lenina, Akademija selskohozjajstvenih nauk imeni V.I. Lenina, Vsesojuznij naučno--issledovatelskij institut zaširi rastenij, Leningrad: 1-23.

Singh P., Sindhu I., Singhal G. 1984. Fungi recorded from seeds and seedlings of *Fagopyrum esculentum*. Journal of the Indian Botanical Society 63 (3): 236-243.

Soba Syubyoo tokuseibenruityoosa hookokusyo. Idensigenbu tansaku doon'yu kenkyuusitu. Syakaihoozin hoorinsuisan Gizyutuzyoo hookyookai 1981, Tokyo: 10-12.

Viennot - Bourgin G. 1949. Les champignons parasites des plantes cultivées. Masson, Paris: 270-273.

Zimmer R.C. 1974. Chlorotic leaf spot and stipple spot, newly described diseases of buckwheat in Manitoba. Can. Plant Dis. Surv. 54 (2): 55-56.

Zimmer R.C. 1978. Downy mildew, a new disease of buckwheat (*Fagopyrum esculentum*) in Manitoba, Canada. Plant Disease Reporter 62 (6): 471-473.

Zimmer R.C. 1984. Incidence and severity of downy mildew of buckwheat in Manitoba in 1979 and 1980. Can. Plant Dis. Surv. 64 (2): 25-27.

BOLEZNI AJDE

Izvleček

Članek opisuje predvsem doslej najdene glivične bolezni ajde pri nas (*Peronospora fagopyri*, *Erysiphe polygoni*, *Ramularia* spp., *Ascochyta fagopyri*, *Phyllosticta polygonarum*) in drugod po svetu. Virusne in bakterijske bolezni na tej poljščini v Sloveniji še niso ugotovljene, sicer pa nekatere že resno ogrožajo pridelovaje ajde v Franciji, Sovjetski zvezi itd.

Fagopyrum 9 (1989): 41-43

Grain and leaf characteristics of perennial buckwheat (*Fagopyrum cymosum* Meissn.)

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Key words: chloroplasts, groat, hull, stomata

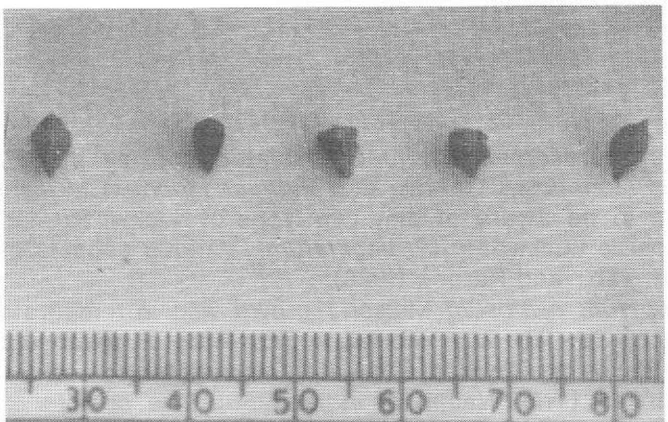
In Kashmir the genus *Fagopyrum* is represented by four cultivated species viz. *F. esculentum* Moench, *F. sagittatum* Gilib., *F. tataricum* Gaertn. and *F. kashmirianum* Munshi (Munshi 1986). However, the farmers seem to be aware of only two types of buckwheat, i.e. common buckwheat (*F. esculentum*) and coarse buckwheat (*F. sagittatum*). Various aspects of the four buckwheats have been reviewed by Tahir and Farooq (1988).

The perennial tetraploid species (*Fagopyrum cymosum* Meissn.) grows wild in temperate Himalayas. Plants of this species produce only few seeds which fail to germinate. *F. cymosum* is principally a fodder plant. However, the leaves are cooked and eaten as vegetable; besides the grains are used in digestive disturbances (The Wealth of India, 1956). The species is cytologically and morphologically distinct and stands out unambiguosly as a separate taxon (Gohil *et al.* 1983). However, during our field trials it was observed that the flowering pattern of *F. cymosum* resembles that of *F. esculentum* in that both produce white flowers and are heterostylous outcrossing species.

Table 1: Grain and leaf characteristics of *Fagopyrum cymosum*.

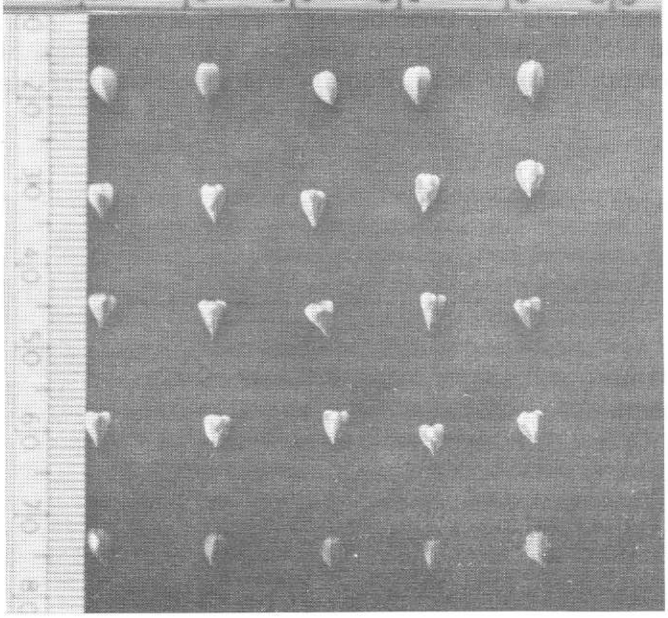
S.No.	Parameter			
1.	100 grain weight (g)		1.55	± 0.08
2.	Grain size (mm)	length	6.2	± 0.42
		breadth	3.1	± 0.31
3.	In air dried grain	hull %	35.25	± 3.22
		groat %	64.73	± 3.22
		hull groat ratio	0.55	
4.	In oven dried grain	hull %	34.97	± 3.95
		groat %	65.01	± 3.95
		hull groat ratio	0.54	
5.	Leaf thickness (μm)		127.12	± 11.23
6.	No. of chloroplasts per cell		9.4	± 1.5
7.	Palisade cell size (μm)	length	26.27	± 3.98
		breadth	10.69	± 2.19
8.	Stomatal frequency/mm^2	lower surface	204.32	± 47.29
		upper surface	14.85	
9.	Stomatal index	lower surface	22.12	± 4.53
		upper surface	1.30	
10.	Stomatal size (μm)	length	26.32	± 1.78
		breadth	17.92	± 1.16
11.	Pore size (μm)	length	19.39	± 1.86
		breadth	4.16	± 0.8

The present note reports various grain and leaf characteristics of *F. cymosum* (Table 1). For the sake of comparison; the grains, groats and plants of the five species of *Fagopyrum* are shown in (Figs. 1 - 3). It was observed that *F. cymosum* possesses a lower grain weight as compared to the other four species, but the grain size resembles that of *F. esculentum* (for comparison, see Farooq and Tahir 1982). A higher stomatal frequency in *F. cymosum* could contribute to its efficient growth.



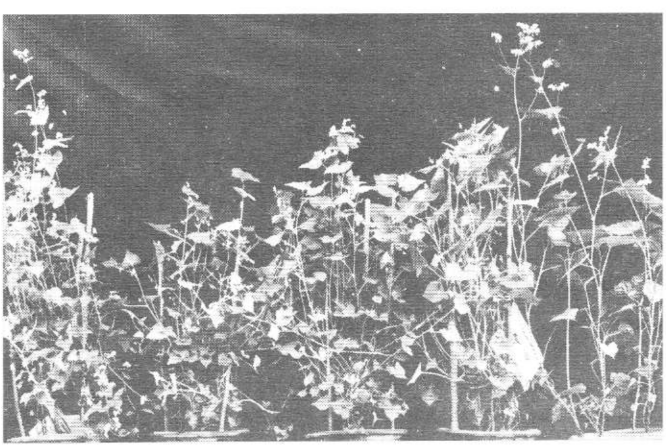
1

Fig. 1: Grains of five species of *Fagopyrum* photographed soon after harvest. From left to right are arranged grains of *F. esculentum*, *F. sagittatum*, *F. kashmirianum*, *F. tataricum* and *F. cymosum*.



2

Fig. 2: Dehulled grains (groats) of five species of *Fagopyrum* photographed soon after harvest. From the top are arranged groats of *F. esculentum* (I row), *F. sagittatum* (II row), *F. kashmirianum* (III row), *F. tataricum* (IV row) and *F. cymosum* (V row).



3

Fig. 3: Plants of five species of *Fagopyrum* in pot culture photographed at eight weeks growth. From left to right are arranged pots with plants of *F. esculentum*, *F. sagittatum*, *F. kashmirianum*, *F. tataricum* and *F. cymosum*.

References

Farooq S. and Tahir I. 1982. Grain characteristics and composition of some buckwheats (*Fagopyrum* Gaertn.) cultivated in Kashmir. J. Econ. Tax. Bot. 3: 877-881.

Gohil R.N., Rathar G.M., Tahir I. and Farooq S. 1983. Comparative cytology, growth and grain composition of West Himalayan buckwheats. Proc. 2nd Intl. Symp. Buckwheat Miyazaki: 87-101.

Munshi A.H. 1986. The taxonomy of genus *Fagopyrum* (Polygonaceae) and its species delineation in Himalayas. Proc. 3rd Intl. Symp. Buckwheat Poland: 162-167.

Tahir I. and Farooq S. 1988. Review article on buckwheat. Fagopyrum 8: 33-53.

The Wealth of India, Raw Materials 4: 1-6. CSIR, New Delhi.

KEMIČNA SESTAVA LISTOV TRPEŽNE AJDE (*Fagopyrum cymosum* Meissn.)

Izvleček

Raziskane so lastnosti listov trpežne ajde, ki kot tetraploidna oblika raste divje v zmernih predelih Himalaje. Rastline te vrste dajejo le malo semen, ki ne kalijo. Uporablja se jo za krmo, liste pa se lahko kuhane uporablja kot zelenjavo. Tako kot prava ajda je tudi trpežna ajda heterostilna in tujeprašna. Podani so podatki o masi in velikosti zrn, o odstotku luščin v zrnju (35%), o debelini listov in o listnih režah. Listnih rež je okoli 200 na mm^2, kar je več kot pri navadni ajdi. Učinkovita rast je lahko povezana z velikim številom listnih rež.

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Growth and yield in four buckwheats (*Fagopyrum* spp.) grown in Kashmir

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Key words: development, *F. esculentum, F. kashmirianum, F. sagittatum, F. tataricum*, grain shattering, pot culture, seed vigour.

Abstract

A pot culture study was carried out to compare growth and yield characteristics of the four species of *Fagopyrum* viz. *F. esculentum*, *F. sagittatum*, *F. tataricum* and *F. kashmirianum*. The percentage of seedling emergence was uniformly high in *F. esculentum*, *F. sagittatum* and *F. kashmirianum*, but in *F. tataricum* seedling emergence was comparatively low. Besides, the appearance of first leaf was somewhat delayed in *F. tataricum*. Flowering and subsequent grain formation occurred earlier in *F. esculentum* than in the other three species. *F. tataricum* outyielded other three species under pot culture conditions. Each of the four species studied here possesses an indeterminate growth habit. The growth span of *F. tataricum* extended over 15-16 weeks, during which period formation of new grains continued. A relatively short growth span characterized the other three species.

Introduction

Among the pseudocereals, buckwheats (*Fagopyrum* Spp., Fam. Polygonaceae) are economically important primarily due to their edible and protein rich grains, hardiness of plants, short growth span; besides foliage being used as a green vegetable (Tahir and Farooq, 1983, 1985; Narain, 1983). Four species of *Fagopyrum* viz. *F. esculentum* Moench, *F. sagittatum* Gilib., *F. tataricum* Gaertn. and *F. kashmirianum* (Munshi, 1982) have been reported to grow in mixed stands at various high altitude areas of Kashmir, where the constraints of adverse climatic conditions permit the cultivation of short duration crops only such as buckwheat (Gohil *et al.* 1983). The crop has received a renewed attention throughout the world owing to its agronomic potential and nutritional status.

Only a little and an incomplete information is available on various phytometric characteristics of buckwheats. Keeping this in view the present experiment was conducted to study some growth and yield characters of buckwheats in pot culture. Moreover the experiment was necessitated by a high incidence of grain shattering observed in *F. tataricum* under field conditions resulting in the lowest yield as also the lowest harvest index for this species (Tahir and Farooq, 1983).

Materials and methods

Plants of each of the four species of *Fagopyrum* viz. *F. esculentum*, *F. sagittatum*, *F. tataricum* and *F. kashmirianum* were raised in 10" earthenware pots filled with 3:1 mixture of garden soil and sand after the central drainage hole was covered with a wad of glass wool to facilitate adequate drainage and root aeration. For each species there were 3 pots. After emergence, abnormal seedlings were removed and the plants were thinned to five uniformly spaced seedlings per pot. The pots were irrigated with water daily and each pot received 250 ml of full nutrient solution at weekly intervals (Hewitt and Smith, 1975).

Observations on growth, flowering and grain formation were recorded for each of the four species. Grains of each of the four species were periodically collected to avoid loss due to shattering particularly in *F. tataricum*. After senescence, when there was no further grain formation, the plants were harvested. The number of the primary lateral branches was counted for each of the four species. The number of grains pooled over the time were counted for each of the four species. The number of grains pooled over the time were counted for each of the four species. The oven dry weight of the pooled plants was determined after drying the plant material in a forced draught oven at 70°C for 48 hours. Air dry weight of the pooled grains for each species was determined after drying the grains for 10 days in open shade and weighed to determine their air dry weight. Harvest index was computed from these data by the formula:

$$\text{Harvest index} = \frac{\text{Grain weight in g}}{\text{Plant dry weight in g}} \times 100$$

Results and discussion

In pot culture studies, some differences were observed between *F. tataricum* and the rest of the three species in respect of seedling emergence. As compared to a low percentage of seedling emergence in *F. tataricum*, the other three species uniformly showed a high percentage of seedling emergence (Table 1). A higher percentage of seed germination as also seed viability has been reported in *F. esculentum*, *F. sagittatum* and *F. kashmirianum* as compared to *F. tataricum* (Tahir and Farooq, 1983). It would appear that the massive hulls in *F. tataricum* as reported by Farooq and Tahir (1982), restrict seed germination in this species. The appearance of first leaf in *F. tataricum* was somewhat delayed owing to a slower initial growth. That the onset of flowering and subsequent grain formation occurred first in *F. esculentum* and last of all in *F. tataricum* is suggestive of the early flowering and early maturing character of *F. esculentum*. The growth span of *F. tataricum* extended over 15-16 weeks and formation of new grains continued during this period. A relatively short growth period of 10-12 weeks, however, characterises the remaining three species. Thus, a short growth span together with a relatively higher seed germinability and viability, quicker seedling growth and higher emergence potential under field conditions in *F. esculentum*, *F. sagittatum* and *F. kashmirianum* suggest a higher seed vigour in these species compared to *F. tataricum*. These observations largely substantiate the the assumption made by Gelmond (1978) that seed vigour is particularly pronounced in short duration crops. In *F. tataricum*, grains shattered as they matured, a character regarded unsuitable for a cultivated grain crop. Moreover, all the

Table 1: Seedling emergence and growth and yield characteristics of four species of *Fagopyrum* in pot culture.

Parameters		*F. escul.*	*F. sagit.*	*F. kash.*	*F. tatar.*
Days to emergence		6	6	6	6
percent emergence	days after sowing 12	78	90	86	38
	14	86	92	94	44
	16	86	94	94	48
Days to unfolding of first leaf		12	12	12	17
Days to flower		31	40	38	42
Day to onset of grains		42	47	48	54
Number of grains per plant at harvest		19	39	53	102
Grain weight (g/plant) at harvest		0.410	0.590	0.886	1.654
Dry weight (g/plant) at harvest		2.10	2.43	2.91	4.60
Harvest index		19.52	24.27	30.44	35.95
Number of primary lateral branches		2.40±0.10	4.33±1.00	4.00±0.10	5.0±0.35
Growth period in weeks		10-12	10-12	10-12	15-16

four species studied here are characterized by an indeterminate growth habit, which restricts yield, since a sizable number of grains go waste at harvest, being at various stages of maturity.

Taking into account the grains shed from plants of *F. tataricum*, when a comparison was made of the net grain yield in the four buckwheat species, *F. tataricum* not only gave the highest grain yield per plant but also maximum dry matter and the largest number of primary lateral branches at harvest (16 weeks growth) as presented in Table 1. When the weight of the shattered grains was included in computing harvest index for *F. tataricum*, maximum value was obtained for this species, which suggests that *F. tataricum* apparently outyields the other three species. Under field conditions, however, lowest grain yield and harvest index is obtained for this species (Tahir and Fafooq, 1983). The potentiality in *F. tataricum* of producing relatively larger number of grains, could perhaps be exploited in a breeding programme aimed at incorporating sheeding resistance in this species as has also been suggested by Kreft (1980).

F. esculentum produced lesser number of grains as also lower dry weight per plant which inturn resulted in a lower harvest index (Table 1). The lower harvest index in *F. esculentum* could be attributed primarily to a high incidence of floral abortion (Tahir and Farooq, 1983). Although the floral abortion in *F. esculentum* has been attributed to heterostyly (Tahir and Farooq, 1987), yet the causative factors underlying floral abortion in *F. esculentum* need further elucidation.

References

Farooq S. and I. Tahir. 1982. Grain characteristics and composition of some buckwheats (*Fagopyrum* Gaertn.) cultivated in Kashmir. J. Econ. Tax. Bot. 3: 877-881.

Gelmond H. 1978. Problems in crop seed germination. Crop Physiology, pp. 1-78. Oxford and IBH Publishing Co. New Delhi.

Gohil R.N., Rathar G.M., I. Tahir and S. Farooq. 1983. Comparative cytology, growth and grain composition of West Himalayan buckwheats. Proc. 2nd Intl. Symp. Buckwheat Miyazaki: 87-101.

Hewitt E.J. and Smith T.A. 1975. Plant Mineral Nutrition, pp. 31-32. The English Universities Press, Ltd. London.

Kreft I. 1980. Starting points for buckwheat breeding in Yugoslavia. Proc. 1st Intl. Symp. Buckwheat Ljubljana: 69-73.

Munshi H. 1982. A new species of *Fagopyrum* from Kashmir Himalaya. J. Econ. Tax. Bot. 3: 627-630.

Narain P. 1983. Buckwheat in India. Fagopyrum 3: 7-11.

Tahir I. and Farooq S. 1983. Growth and yield characteristics of some buckwheats (*Fagopyrum* Gaertn.) from Kashmir. Geobios 10: 193-197.

Tahir I. and S. Farooq. 1985. Grain composition in some buckwheat cultivars (*Fagopyrum* Spp.) with particular reference to protein fractions. Qual. Plant. Plant Foods Hum. Nutr. 35: 153-158.

Tahir I. and S. Farooq. 1987. Breeding systems in buckwheat (*Fagopyrum* Spp.) cultivated in Kashmir. Genetika 19: 205-208.

RAST IN PRIDELEK ŠTIRIH VRST AJDE V KAŠMIRJU

Izvleček

V lončnem poskusu so bile primerjane rastline navadne ajde (*Fagopyrum esculentum*), koničastolistne ajde (*F. sagittatum*), tatarske ajde (*F. tataricum*) in kašmirske ajde (*F. kashmirianum*). Odstotek vznika rastlin je bil visok pri navadni, koničastolistni in kašmirski ajdi, a razmeroma nizek pri tatarski ajdi. Poleg tega se je pri tatarski ajdi prvi list pojavil nekoliko kasneje. Cvetenje in prva semena so bila pri navadni ajdi nekoliko prej kot pri ostalih treh vrstah. V lončnem poskusu je dala tatarska ajda največji pridelek. Vse štiri proučevane ajde so imele nedeterminantno rast. Rast tatarske ajde je trajala 15 - 16 tednov, ob koncu tega obdobja so se še pojavljala nova zrna. Obdobje rasti je bilo krajše pri ostalih treh vrstah.

Fagopyrum 9 (1989): 47-48

Morphological studies on the location and size of the buckwheat embryo

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Several authors have discussed the general structure of the buckwheat kernel (Pomeranz and Sach 1972, Kreft and Javornik 1979, Marshall and Pomeranz 1982) where the only allusion to the germ has been to describe the two large cotyledons (occasionally three) folded like an "S" through the endosperm. The embryo proper, however, also an integral component of the germ has not been discussed.

The germ in general, is of high nutritive value as most of the buckwheat proteins are concentrated in this seed structure (Pomeranz 1973, Eggum et al. 1981, Javornik 1983, 1986; Ikeda 1987). According to Shiratori and Nagata (1987) and Shiratori (personal communication) the proteins of buckwheat are very important for the production of soba noodles in Japan. Therefore, the kernel structure has a bearing on the noodle-making quality of the buckwheat flour. This technological value of buckwheat grains may be improved by breeding for larger germs.

In this preliminary study, 15 samples from the buckwheat gene bank at the Biotechnical Faculty of the University of E. Kardelj Ljubljana, were used. The buckwheat kernels were individually sliced into 20 cross-sections from top to bottom and each section was microscopically examined to estimate the relative size and location of the embryo proper.

It was possible to locate the embryo in the sections taken from the terminal end of the kernel. In other sections, only the folded cotyledons could be seen. As for the quantification of the embryo and cotyledons, only relative estimates were possible because these velues changed significantly according to where the sections were taken from. The embryo proper was relatively small, consisting of less than 10% of the total germ. A fluorescence micrograph of a cross-section taken from the tip of a kernel, is presented on the cover of this issue of Fagopyrum.

It is desirable to develop a simple, quick, inexpensive and preferably a non-destructive method for estimating the exact location and size of the embryo proper in the seed, as influenced by genetic variability. This could be very useful for breeding purposes. The preliminary microscopical method here presented, does not seem to be very practical. However, quantification by image analysis of a significant sample of seeds, may prove to be beneficial. Another possible method could be nuclear magnetic resonance (NMR). This method has been successfully used in the area of corn breeding for higher oil content (Ratković 1982) and in the studies on the variation of germ size in barley (Kreft et al. 1986).

References

Eggum B.O., Kreft I., Javornik B. 1981. Chemical composition and protein quality of buckwheat (*Fagopyrum esculentum* Moench). Qual. Plant Foods Hum. Nutr. 30: 175-179.

Ikeda K. 1987. Analysis of the inhibitory factors against the protein digestibility of plant foodstuffs. Kyoto University. 1-105.

Javornik B. and Kreft I. 1980. Structure of buckwheat kernel. Buckwheat, Symp. Ljubljana, Sept. 1-3, 1980: 105-113.

Javornik B. 1983. Nutritional quality and composition of buckwheat proteins. Buckwheat Research 1983, Proc. 2nd Intl. Symp. Buckwheat Miyazaki, 7-10 Sept.: 199-212.

Javornik B. 1986. Buckwheat in human diets. Buckwheat research 1986, Proceedings of the 3rd International Symposium on Buckwheat, Pulawy, Poland, 7-12 July 1986: 51-78.

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Kreft I. and Javornik B. 1979. Buckwheat as a potential source of a high-quality protein. Seed protein improvment in cereals and grain legumes, IAEA, Vienna: 377-384.

Kreft I., Rutar V., Luthar Z., Javornik B. 1986. Ugotavljanje velikosti kalčka in vsebnosti olja z NMR pri žlahtnjenju visokolizinskega ječmena. Zbornik BF 47: 25-31.

Marshall H.G. and Pomeranz Y. 1982. Buckwheat : description, breeding, production, and utilization. *In*: Advances in Cereal Science and Technology, Ed. Y. Pomeranz, St. Paul, Minnesota. pp. 157-210.

Pomeranz Y. and Sachs I.B. 1972. Scanning electron microscopy of the buckwheat kernel. Cereal Chem. 49: 23-25.

Pomeranz Y. 1973. A review of proteins in barley, oats, and buckwheat. Cereal Sci. Today: 18: 310-315.

Ratković S. 1982. The use of pulsed ^{1}H NMR techniques in breeding new high oil hybrids of maize. *In*: New Techniques and Applications of Magnetic Resonance, Eds. R. Blinc and M. Vilfan, IJS Ljubljana.

Shiratori R. and Nagata Y. 1986. Utilization of buckwheat in modern Japan. Fagopyrum 6: 23-46.

RAZISKAVA VELIKOSTI KALČKA V ZRNIH AJDE

Izvleček

Pri dosedanjih študijah zgradbe zrn ajde so avtorji poročali predvsem o tem, kako sta klična lista razporejena v endospermu, manj pa so se posvečali samemu kalčku v ožjem pomenu besede. Avtorja sta ugotovila, da je kalček v zgornjem delu zrna ajde. Ugotovljeno je tudi, da na osnovi prerezov zrn ajde ni možno sklepati o relativnem deležu kalčka v semenu ajde. Za to bi bila verjetno primernejša metoda nuklearne magnetne resonance, ki se je pokazala kot uspešna že pri koruzi in ječmenu.

Fagopyrum 9 (1989): 49-52

Weed control in buckwheat (*Fagopyrum esculentum* Moench) in the region of Slavonia

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Key words: climate factors, efficacy coefficients, herbicides, weed species

Abstract

Efficacy of some herbicides and their combination was tested in buckwheat, grown as a catch crop in 1988 in the region of Slavonia. In terms of weed infestation, the dominating species by individual plant mass were Dicotyledoneae, which were under prevailing conditions of arid climate more competitive than Monocotyledoneae. The most efficient combination of herbicides in this trial was Bravo + Dicofluid MP Combi at a rate of 5 + 2.5 l/ha.

Introduction

As a catch crop buckwheat is usually cultivated mainly in the north-western part of SR Croatia. It is less known that this important crop has been regularly cultivated on some production farms of the Slavonia region. For instance, at the acreage of WO Feričanci buckwheat has been successfully cultivated as catch crop for the past two decades. This was the reason to do some floristic investigations in buckwheat grown in this area of north-eastern part of SR Croatia (Knežević *et al.* 1987), which were also done in SR Slovenia (Ratnik 1977, Bohanec and Retelj 1986) and in some other countries (Vlasova 1976, Komenda *et al.* 1980, Friesen and Campbell 1985).

This paper presents the results of investigation on floristic composition and quantitative share of weed species in buckwheat, as well as efficacy of herbicides applied to weeds in 1988.

Material and methods

The herbicide efficacy for control of weeds in buckwheat was investigated on a flat terrain with pseudogley soil type in the frames of acreage belonging to Agricultural WO Feričanci, where the buckwheat cultivar Siva was planted in 1988 on July 11, following the wheat crop. The sowing was done in narrow continual rows with a distance between the rows of 12.5 cm and in the row of 12 cm. Prior to sowing the soil was fertilized with 200 kg/ha of NPK 10:30:20 and 150 kg/ha of urea. Dressing was done prior to flowering of the crop with 100 kg/ha of nitrogen fertilizer (27% of KAN).

The trial was established on the plots of 25 m^2 size and by the block method with four replications. The following herbicides and their combinations were tested: Dual 500 EC, Bravo, Targa, Dual 500 EC + Deherban A, Dual 500 EC + Dicofluid MP Combi, Bravo + Deherban A and Bravo + Dicofluid MP Combi. All chemicals except Targa were applied on the same day after sowing, while the Targa chemical was applied in time when the weed species of Monocotyledoneae developed three to six leaves (August 25). The rates, mode of application and active ingredients of chemicals are presented in Table 1.

Weed infestation of the crop was found in all variants of the trial by counting the number of weed shoots per m^2 and after 15, 30 and 60 days of treatment with herbicides. At the same time, phytotoxicity of herbicides for buckwheat was visually estimated according to EWRC. The mass of dry matter of weeds per m^2 was determinated at time of full weeds development in the season and on the plots where simultaneously the buckwheat was harvested by hand (October 314. The grain yields with 14% of moisture were expressed in kg/ha. Clima conditions in the year of investigation are presented by the clima diagram according to Walter (Fig. 1).

The nomenclature of plant species was taken according to Ehrendorfer (1973). The data were processed according to usual statistical methods (Snidikor and Kohren 1971).

Table 1. Comparison of herbicides as of their active ingredients, mode of application and rates of application to buckwheat

Herbicide	Contents of a. i.	Rates (l/ha)	Mode of application
Dual 500 EC	50% metolachlor	3	after sowing
Bravo	48% alachlor	5	after sowing
Targa	10.4% quizalofop-ethyl	1.5	after emergence
Deherban A	46% 2,4-D	1.5	after sowing
Dicofluid MP Combi	43% mecoprop+13% 2,4-D	2.5	after sowing

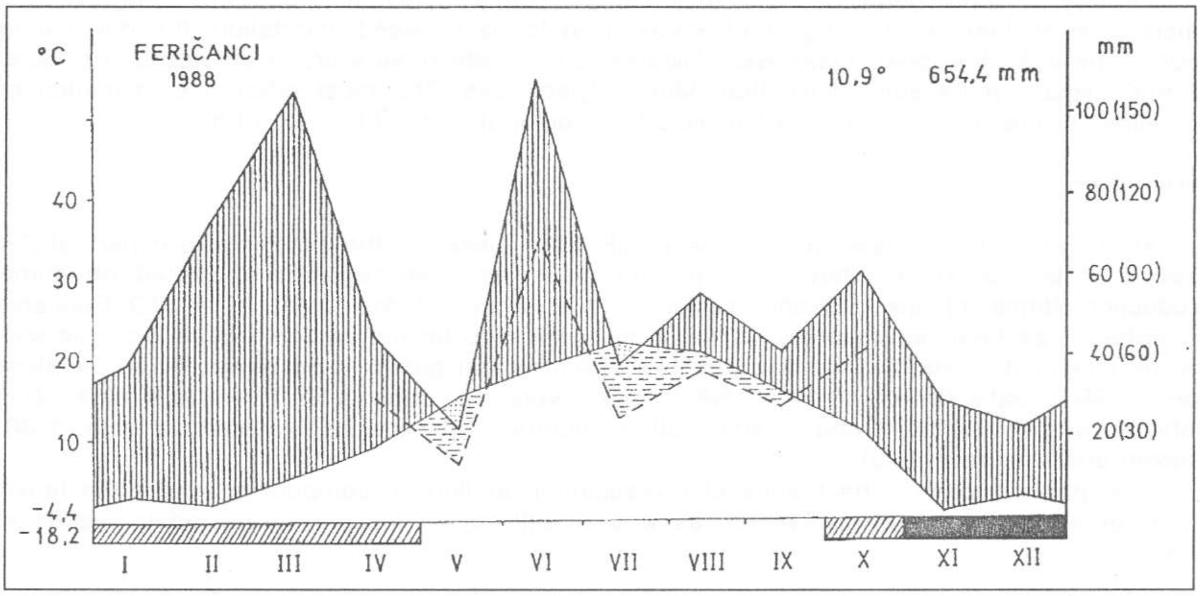

Fig. 1. Clima diagram according to Walter for Feričanci in 1988

Results and discussion

In composition of weed flora of this buckwheat a total of 14 species were evidented out of which four were species of Monocotyledoneae and the remaining belonging to Dicotyledoneae (Table 2). Among Monocotyledoneae a dominating species was *Echinochloa crus galli* with an average of 72 plants per m^2 and that in September, when the buckwheat was in the stage of flowering (September 10). Prolonged dry period in the summer months retarded the growth of this late spring weed species so that it was less numerous in buckwheat in 1988 than in former years (Knežević *et al.* 1987). This is also confirmed by considerably lower values of average plant dry matter share of 15.8 g/m^2 for individuals of *Echinochloa crus galli* in control plots just prior to harvesting.

Among the Dicotyledoneae the most numerous species was *Chenopodium album* with an average of 21 individuals per m^2 and share of dry matter mass of 12.8 g/m^2 in the weed composition. In total mass of Dicotyledoneae of 167.8 g/m^2, 88% of share belonged to Raphanus sativus var. oleifera species, which is also cultivated as stubble crop in this region with an objective to provide green manuring of production plots, but infesting later the buckwheat to a considerable extent. Other Dicotyledoneae such as *Amaranthus retroflexus, Ambrosia artemisiifolia, Polygonum lapathifolium, Solanum nigrum* and *Stellaria media* achieved lower values of mass (7.4 g/m^2) in this weed composition. The climate conditions in the investigated year favoured more to the development of Dicotyledoneae, which infested the buckwheat more than Monocotyledoneae.

A, Dual 500 EC + Dicofluid MP Combi and Bravo + Deherban A were not quite effective in killing of broadleaved weeds and had efficacy coefficients for Dicotyledoneae ranging from 39.1% to 81.5%. The most effective combination of herbicides in control of Dicotyledoneae weeds was Bravo + Dicofluid MP Combi at rate of 5 + 2.5 l/ha, with an efficacy coefficient of 87.4%.

The yields of buckwheat grain varied according to variants from, in average, 1117 kg/ha to 1935 kg/ha on treated plots. The differences in yields were statistically very significant between the lowest on the control plot and yield attained with treatments of Bravo + Dicofluid MP Combi, Bravo + Deherban A, Bravo, Dual 500 EC + Deherban A and Dual 500 EC + Dicofluid MP Combi, as well as significant between the control and variant Dual 500 EC, what justifies the application of preemergence herbicides in buckwheat. The best results were attained in plots which were treated with combinations of herbicide chemicals Bravo + Dicofluid MP Combi at rate 5 + 2.5 l/ha, where the infestation was the lowest one and the buckwheat uniform and with the highest yield of grain.

The climate conditions during the summer months with shorter or longer periods of drought have significant and various effect on the efficacy of herbicide chemicals applied for weed control to buckwheat. This is particularly pronounced in semiarid region of SR Croatia, what imposes the need for further investigations in various climatic years aiming at proper choice of the most effective herbicides for the weeds control in buckwheat cultivated in this region.

Table 2. Number of weed species individuals per m^2 in the stage of buckwheat flowering (10.9.1988)

Treatment	Control	Dual 500 EC	Bravo	Dual 500 EC +Deherban A	Dual 500 EC + Dicofluid	Bravo + Deherban A	Bravo + Dicofluid	Targa
Rate (l/ha)		3	5	3 + 1.5	3 + 2.5	5 + 1.5	5 + 2.5	1.5
WEED SPECIES								
Monocotyledoneae								
Digitaria sanguinalis (L.) Scop.	0.9	-	-	-	-	-	-	-
Echinochloa crus galli (L.) PB.	72.0	0.3	-	1.0	0.3	-	0.5	-
Setaria glauca (L.) PB.	1.5	-	-	-	-	-	0.3	-
Triticum vulgare L.	0.5	-	-	-	-	-	-	-
Total	74.9	0.3	-	1.0	0.3	-	0.8	-
Efficacy coefficients (%)		99.6	100.0	98.7	99.6	100.0	98.9	100.0
Dicotyledoneae								
Amaranthus retroflexus L.	2.8	-	-	-	-	-	-	6.0
Ambrosia artemisiifolia L.	0.3	0.3	0.6	0.3	0.3	0.3	0.3	-
Chenopodium album L.	21.0	10.5	2.8	15.8	10.0	2.8	1.8	3.5
Diplotaxis muralis (L.) DC.	0.3	-	-	-	-	-	-	0.3
Hibiscus trionum L.	0.5	-	-	-	-	-	-	0.5
Polygonum lapathifolium L.	2.0	1.0	0.5	0.8	1.0	0.8	0.8	1.5
Raphanus sativus L. *var. oleifera*	8.5	5.3	7.5	6.8	3.8	3.3	2.0	4.3
Solanum nigrum L.	1.0	-	-	-	-	-	-	-
Stellaria media (L.) Vill.	2.0	-	-	-	-	-	-	8.5
Veronica persica Poir.	0.5	-	-	-	-	-	-	0.5
Total	38.9	17.1	11.4	23.7	15.1	7.2	4.9	25.1
Efficacy coefficients (%)		56.0	70.7	39.1	61.2	81.5	87.4	35.5

Table 3. Comparison between the number of buckwheat plants and weed plants on sprayed and control plots and effect of herbicides on the seed yield

Treatment	Rate l/ha	No. of plants per m² Buckwheat	Weeds	Efficacy coefficients (%)	Grain yield kg/ha
Control	-	137.5	113.8	-	1117
Dual 500 EC	3	165.3	17.4	84.71	1465
Bravo	5	137.8	11.4	89.98	1848
Dual 500 EC + Deherban A	3 + 1.5	155.5	24.7	78.30	1749
Dual 500 EC + Dicofluid MP Combi	3 + 2.5	134.3	15.4	86.47	1792
Bravo + Deherban A	5 + 1.5	140.0	7.2	93.67	1877
Bravo + Dicofluid MP Combi	5 + 2.5	141.5	5.7	94.99	1935
Targa	1.5	150.5	25.1	77.94	1375
LSD	0.05				328
	0.01				446

Acknowledgement

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References

Bohanec B. and Retelj H. 1986. Chemical weed control in buckwheat (*Fagopyrum esculentum* Moench). Fagopyrum 6: 17-20.

Ehrendorfer F. 1973. Liste der Gefässpflanzen Mitteleuropas. GFV Stuttgart, p. 318.

Friesen G. and Campbell G.C. 1985. Common Buckwheat (*Fagopyrum esculentum*) Tolerance to Herbicides. Morden, Manitoba, Canada.

Knežević M., Djurkić M., Buljan V., Baketa E. 1987. Korovna flora u heljdi (*Fagopyrum esculentum* Moench) i mogućnost njezinog suzbijanja. Nauka u proizvodnji 15 (1-2): 57-62.

Komenda K., Komenda B., Dabrowski M. 1980. Weed control in buckwheat. Buckwheat Symp. Ljubljana, Sept. 1-3, Suppl. Vol.: 37-43.

Ratnik O. 1977. Možnosti zatiranja plevela v ajdi. Diplomsko delo, Ljubljana, p. 1-46.

Snidikor D.V., Kohren V.G. 1971. Statistički metodi (prijevod). Vuk Karadžić, Beograd. p. 511.

Vlasova E.P. 1976. Chemical control of weeds in buckwheat in Orel province. Byulleten Nauchnotekhniceskoi Informatsii, Vsesoyuznyi Nauchnoissledovateliskii Institute Zernobobovykh Krupyanykh Kultur No. 16: 80-83. (From Field Crop Abs. 32, 7175).

KONTROLA KOROVA U HELJDI NA PODRUČJU SLAVONIJE

Izvod

U heljdi, na području Slavonije ispitano je u 1988. godini djelovanje nekih herbicida i njihovih kombinacija na korovne vrste. Najefikasnija kombinacija herbicidnih preparata bila je Bravo + Dicofluid MP Combi u dozi od 5 + 2.5 l/ha.

Specific leaf area of two buckwheat cultivars in different stages of stand development

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Key words: diploid, dry matter, growth, photosynthesis, tetraploid

Abstract

The leaf dry matter, leaf area and Specific Leaf Area (SLA) in three stages of stand development (1 - plants with 6 to 8 leaves, 2 - full flowering, 3 - most grain mature) of two buckwheat (*Fagopyrum esculentum* Moench) cultivars (diploid cv. Siva and tetraploid. cv. Bednja 4n) were studied. The differences among cultivars and all three stages were found statistically significant. It is shown by linear regression that leaf dry mass gives a good estimate of leaf area for both cultivars with an accuracy of 99%.

Introduction

Growth analysis is still a powerful method for estimating net photosynthetic production and for analysing physiological adaptations of different species in terms of their partitioning of carbohydrate into leaves and other organs such as roots or seeds. It is based on measurement of plant dry weight and leaf dimensions made at intervals on growing plants or plant stands.

Estimation of leaf area is an essential component of plant growth analysis and evapotranspiration studies. At present a great variety of methods are available for leaf area measurement (Ross 1981). The estimation of leaf area by direct methods is time-consuming and expensive. Therefore we tried to establish a relationship between leaf area and leaf dry matter, knowing that a close correlation exists between them. (Pearce *et al.* 1969, Aase 1978, Ramos et al. 1983).

Specific Leaf Area (SLA) is defined (Hesket and Jones 1980) as the ratio of leaf area (A) to total leaf dry matter (W). Some authors use the same term SLA for ratio of leaf area to fresh weight of leaf (Larcher 1980). SLA is not constant during plant development, due to different leaf adjustments to light environment (Björkman 1981), temperature (Hesket and Jones 1980) or to partitioning of carbohydrate into leaves. SLA increases as the temperature increases, or the leaves become lighter. There are also differences among different species (Driessen 1987) and even among cultivars of the same species.

Knowledge of buckwheat growth characteristics regarding relations between leaf area and leaf mass are still incomplete in spite of some studies (Kajfež-Bogataj and Knavs 1985, Farooq and Tahir 1987). So we focused our research on the study of these components of buckwheat growth analysis.

Material and methods

A 2 x 3 factorial experiment in a randomized complete block design with four replications was conducted on gleic soil at Ljubljana (46° 04 N latitude and 14° 31 E longitude and at an altitude 300 m above sea level). Specific leaf area was studied on two buckwheat cultivars (diploid Siva and tetraploid Bednja 4n). Plants were sampled at three different development stages: plants with 6 to 8 leaves (31 days after sowing), full flowering (52 days after sowing) and most grain mature (76 days after sowing). Plants were sown on 26 May 1986 on 24 plots (0.6 m x 1.0 m each) in 3 rows per plot (spaced 0.2 m apart) with density 40 seeds per row.

At each sampling only plants from center row were cut, leaves were removed and dried. Leaf area per plant was established by using a photoelectric areameter (LI-COR model LI-3050-A). For the estimation of leaf weight the herbarized material was dried in an owen at 105°C for 1 hour. The results were analysed using analysis of variance and standard regression and correlation methods.

Results and discussion

Summarizing statistical analysis in an ANOVA table we get Table 1. The results show that stage of development has a very decided effect on SLA and that type of cultivar also affects value of SLA but there is no significant interaction. The fact that two curves on Fig.1 are nearly parallel demonstrates little or no interaction between cultivars and stage of development.

Table 1: ANOVA for cultivar and stage of development: 2 x 3 with 4 blocks per cell

source	df	F
treatments	5	44.60**
-cultivars	1	5.41*
-stages of development	2	108.77**
-interaction	2	0.03
blocks	3	0.61
error	15	

It is obvious that in the stage of full flowering, SLA has maximum value for both cultivars and minimum at the end of growing period, which represents around 60% of maximum value (Table 2). The value of SLA for cultivar Siva is about 10% higher than for Bednja 4n through the whole growing period. The average value of SLA over both cultivars and over three stages of development is 26.3 m^2kg^{-1}, which corresponds quite good to the average values of SLA for others crops (barley 25 m^2kg^{-1}, soybean 26 m^2kg^{-1}, wheat 20 m^2kg^{-1}, rice 25 m^2kg^{-1}) found in literature (Driessen 1987).

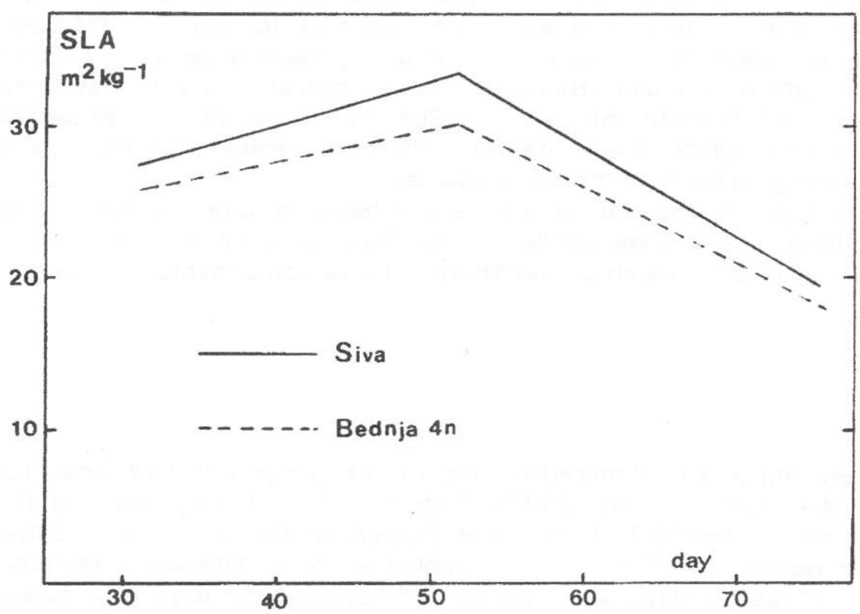

Fig. 1 : Specific leaf area for two buckwheat cultivars at three stages of stand development

We were also interested in a functional relation between the leaf dry matter and the leaf area. We fitted a straight line to set of paired observations (W - leaf dry matter per plant and A-leaf area per plant) for each cultivar and for each development stage. The mathematical expression for six different lines which were obtained is $A = aW + b$, where a represents the slope and b the intercept. The correlation coefficients which provide a measure for goodness of fit are highly significant (from 0.949 to 0.979). The leaf dry matter is found to be very accurate estimate for leaf area in buckwheat. By substituting the leaf dry mass in the regression equations given in Table 2 one can easily estimate the leaf area with an accuracy of 99%. Two examples of linear regression are presented as illustration of small residual errors on Fig. 2.

Table 2: Specific leaf area parameters : number of plants (N), mean value (mean), standard deviation (SD), maximum (max) and minimum (min) value and regression coefficients: slope (a), intercept (b) and correlation coefficient (r) for two buckwheat cultivars: Siva (S) and Bednja 4n (B) at three stages of developments (1,2,3)

		SPECIFIC LEAF AREA				REGRESSION (A = aW+b)		
	N	mean (m^2kg^{-1})	SD	max	min	a (m^2kg^{-1})	b (m^2)	r
S1	131	27.9	5.03	45.3	15.0	22.45	0.59	0.950**
S2	141	33.6	6.87	54.2	16.5	25.14	1.54	0.952**
S3	98	19.7	5.20	37.4	10.7	16.26	0.47	0.950**
B1	137	25.9	4.63	51.8	18.7	20.68	0.59	0.949**
B2	124	29.9	4.99	49.0	20.7	26.07	0.70	0.979**
B3	119	18.1	3.94	30.2	11.6	15.21	0.36	0.954**

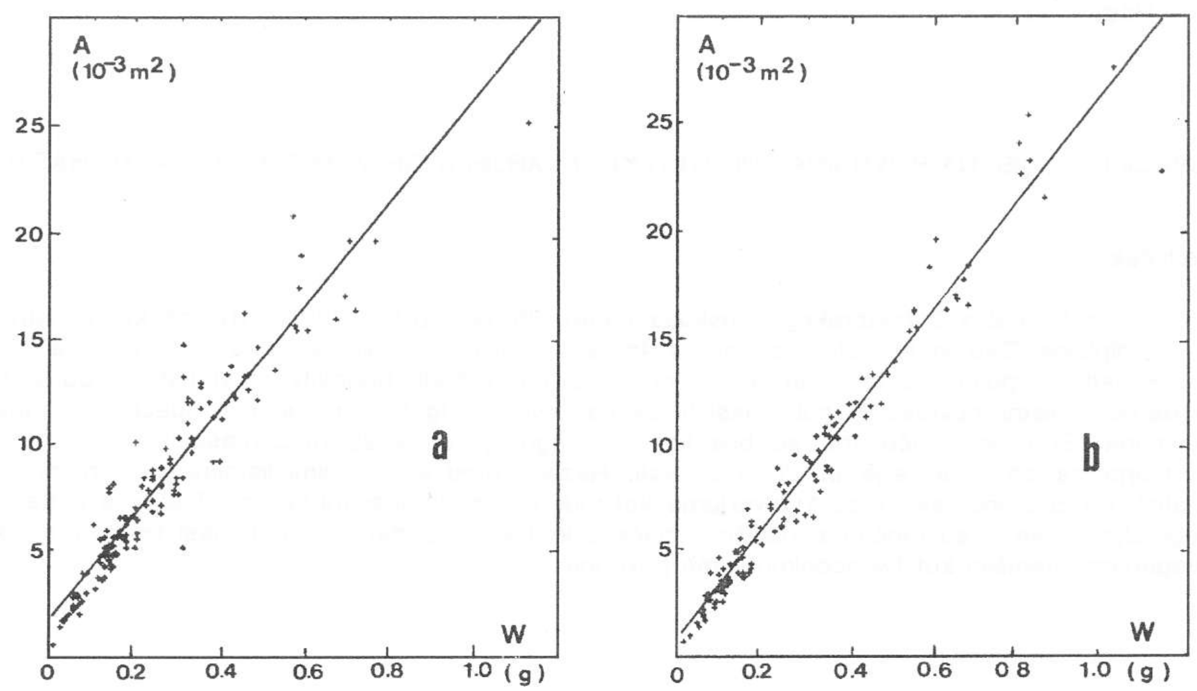

Fig. 2 : Examples of linear regression for relation of leaf dry matter to leaf area per plant at stage of full flowering for: a - cultivar Siva and b - cultivar Bednja 4n

Conclusion

The present study suggests that specific leaf area of buckwheat (*F. esculentum* M.) changes during stand development, reaching its maximum value in the middle of growth period in stage of full flowering. Considerable differences might be expected among different cultivars. Strong correlation between leaf dry matter and leaf area is evident for both studied cultivars throughout the growing period.

References

Aase J. K. 1978. Relationship between leaf area and dry matter in winter wheat. Agron. J. 70: 563-565

Björkman O. 1981. Responses to Different Quantum Flux Densities. In: Physiological Plant Ecology I, Spriger-Verlag, Berlin, 57-108

Driessen P.M. 1987. A First Intriduction to Land Evaluation Procedures. Agric. Univ. Wageningen, Netherlands, 115 p.

Farooq S. and Tahir I. 1987: Comparative study of some growth attributes in buckwheats cultivated in Kashmir. Fagopyrum 7: 9-12

Hesketh J.D. and Jones J.W. 1980. Integrating traditional growth analysis techniques with recent modeling of carbon and nitrogen metabolism. In: J.D. Hesketh J.D. and J.W.Jones (Eds.), 1980. Predicting photosynthesis for ecosystem models. Vol.I. CRC Press Inc., Boca Raton, Florida. 51-92

Kajfež-Bogataj L. and Knavs M. 1985. Studies on the production of dry matter in the community of buckwheat with particular reference to leaf area. Fagopyrum 5: 7-13

Larcher W. 1980. Physiological plant ecology. Springer-Verlag, Berlin. 303 p.

Pearce R.B., Carlson G.E., Barnes D.K., Hart R.H. and Hanson C.H. 1969. Specific leaf weight and photosynthesis in alfalfa. Crop Science 7-8 (9): 423-426

Ramos J.M., Del Moral L.F.G. and Recalde L. 1983. Dry matter and leaf area relationships in winter barley. Agron. J. 56: 520-522

Ross J. 1981. The radiation regime and architecture of plant stands. W.J. Junk Publishers, Hague. 391 p.

SPECIFIČNA LISTNA POVRŠINA PRI DVEH KULTIVARJIH AJDE V RAZLIČNIH FAZAH RASTI

Izvleček

Na osnovi 2 x 3 faktorskega poskusa (setev 26/05 - žetev 1/09) z dvema kultivarjema ajde (diploida Siva in tetraploidna Bednja 4n) smo v treh različnih fazah rasti (1 - rastline z 6 do 8 listi, 2- polno cvetenje in 3- tik pred žetvijo) v štirih ponovitvah, statistično obdelali podatke o listni površini in suhi masi listov na rastlino. Ugotovljena je bila specifična listna površina (SLA) in izračunane so bile linearne regresijske zveze med maso listov in listno površino za oba kultivarja in tri faze rasti. Razlike med specifičnimi listnimi površinami so statistično značilne tako med kultivarjema kot tudi med posameznimi fazami. Tudi vse podane regresijske zveze so močno statistično značilne in tako s podatki o suhi masi listov lahko s tveganjem manjšim kot 1% ocenimo listno površino.

Breeding of determinate buckwheat

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Key words: ideotype, lodging resistance, photosynthates, yield

Abstract

Studied determinate buckwheat exhibits characters which may help to control buckwheat growth and development and this may be the basis for an ideotype of high yielding buckwheat (Figs. 1-4).

More intense branching may be controlled by higher density, higher optimal density in determinate buckwheat may be one of the important factors for achieving higher yields. Higher density in buckwheat may even increase existing good competitive ability of buckwheat in comparison to most weeds.

Introduction

Buckwheat is a crop of some importance in Nepal, India, Pakistan, Afghanistan, Iran, China, Japan, Korea, USSR, Poland, Hungary, Yugoslavia, Denmark, France, Canada, USA and Brazil. Growing of buckwheat has also been reported from Bhutan, CSSR, Austria, Switzerland, Italy, Great Britain, Finland and Australia.

Buckwheat is a typical low input plant. Many buckwheat varieties have a very short vegetation period. Some domestic buckwheat populations in Yugoslavia need only about 60 days from sowing to harvest. It is an undemanding crop, grown on sandy soils poor in nitrogen and on stony fields. Higher doses of nitrogen fertilization cause lodging. Buckwheat is a good utiliser of soil phosphorus (Andersen and Thomsen 1978), but modest fertilisation with phosphorus may sometimes improve yields. Buckwheat roots have good K/Na selectivity (Eggers and Jeschke 1983).

Common buckwheat needs a relatively high temperature for germination (about 10°C), but at optimal temperatures (about 20° C) and moisture it may emerge in 2 or 3 days after sowing. Buckwheat has relatively low optimal temperatures (Kajfež-Bogataj and Gaberščik 1986) and is thus chilling resistant. But it is not freezing resistant, it is damaged at temperatures of about -2°C (Gaberščik *et al.* 1986).

Buckwheat is not sensitive to diseases and pests and there is normally no need for application of insecticides, fungicides or herbicides. In Yugoslavia, most harm to buckwheat is caused by roe-deer, and sometimes by birds.

Buckwheat has low yields, mostly in the range 0.5 to 2 tonnes per hectar, yields have not changed much in this century. Wheat yields have in this time increased five to ten times. Common buckwheat is a cross pollinated self-incompatible plant and thus is not suitable for improvement by conventional plant breeding methods. So it still has poor response to high rates of fertilizers, has an indeterminate growth habit, is not lodging resistant, ripening of kernels is not simultaneous and the first ripe kernels often fall off before last kernels are ripe. Usually buckwheat plants have many more flowers than they are able to bear or fill kernels. Overproduction of flowers is significant waste of organic matter, water and minerals from the point of view of allocation of photosynthates, although a part of them are probably removed from the flowers before they desiccate.

In short: buckwheat is today much more simmilar to a weed or even to a wild plant than to a modern high-yielding crop.

To improve buckwheat yields, it is necessary to form an ideotype of high yielding buckwheat.

Material and methods

Growth and development of comparable buckwheat types with respective genes for dwarf and determinate growth were studied.

Results and discussion

Lodging resistance could be improved by dwarfing genes and by genes for the determinate growth habit. The determinate types are very promising.

Studied recessive gene for the determinate growth habit from a sample of Yugoslav origin has pleiotropic effects: cessation of further growth of the apex and of development of new leaves and inflorescences; earlier and more uniform ripening of kernels, less shedding of kernels; higher number of kernels per inflorescence; plants are lower and more resistant to lodging; development of plants, flowering and ripening time are less photoperiodic sensitive; and the harvest is relatively early, when the leaves are still green. After the cessation of further growth of the apex of the main stem, more intense side branching appears.

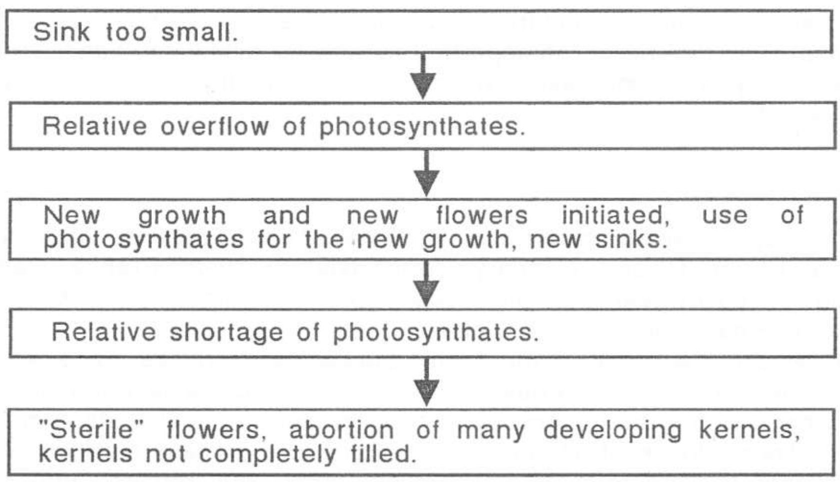

Fig. 1: Development pathway in buckwheat when sink is too small in relation to available photosynthates.

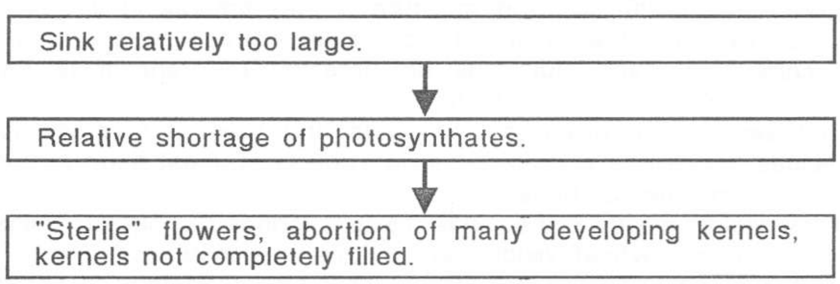

Fig. 2: Development pathway in buckwheat when sink is too large in relation to available photosynthates.

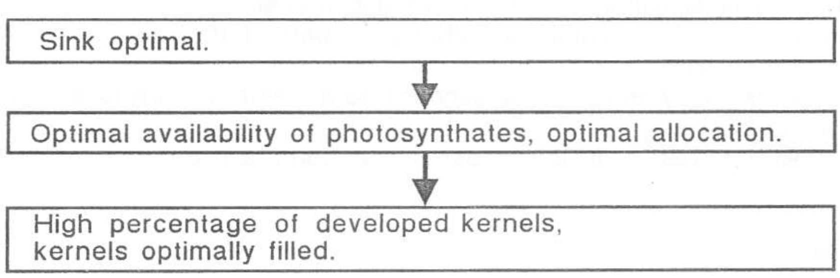

Fig. 3: Development pathway in buckwheat when sink is optimal.

Studied determinate buckwheat exhibits characters which may help to control buckwheat growth and development and this may be the basis for an ideotype of high yielding buckwheat (Figs. 1-4).

More intense branching may be controlled by higher density, higher optimal density in determinate buckwheat may be one of the important factors for achieving higher yields. Higher density in buckwheat may even increase existing good competitive ability of buckwheat in comparison to most weeds.

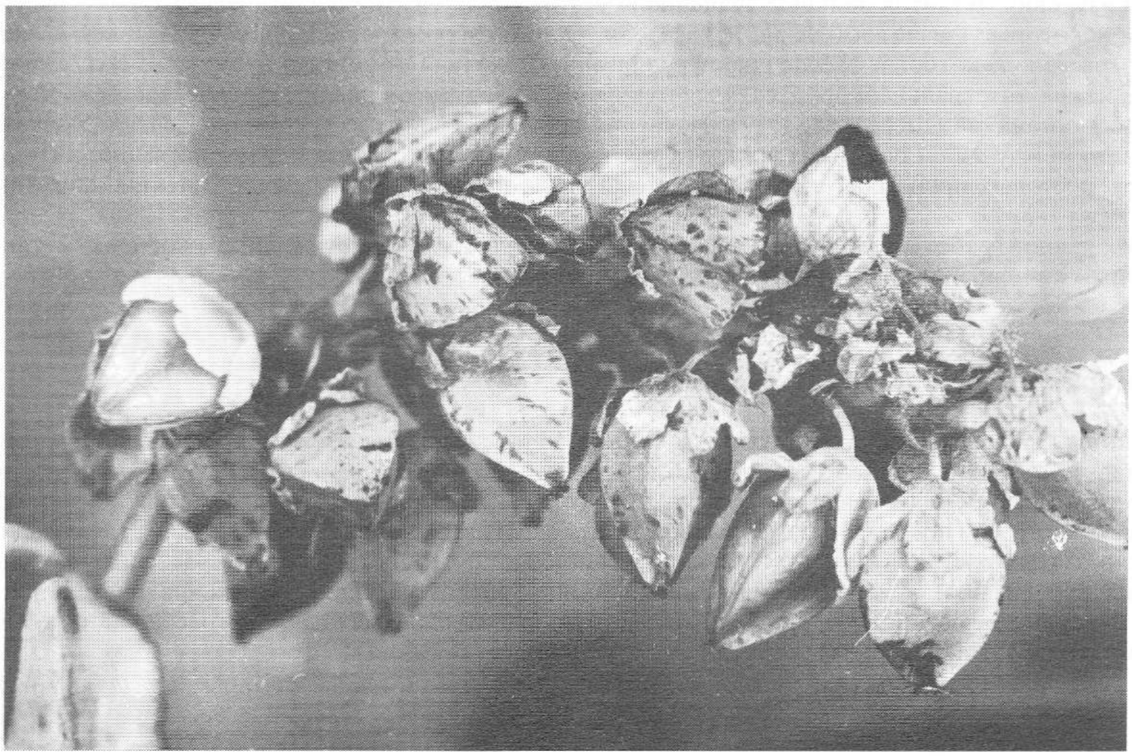

Fig. 4: Ripening determinate buckwheat cv. 'Siva'.

References

Andersen A.J. and Thomsen J.D. 1978. *In:* International Symposium on the Use of Isotopes and Radiation in Research on Soil-Plant Relationships, 1-5. IAEA-SM-235/7, Colombo, Sri Lanka.

Eggers H. and Jeschke W.D. 1983. *In:* Genetic Aspects of Plant Nutrition. Martinus Nijhoff/Dr. W. Junk Publ., The Hague, pp. 223-228.

Gaberščik A., Mařtinčič A., Kajfež-Bogataj L., Kreft I. 1986. Fagopyrum 6: 10-11.

Kajfež-Bogataj L. and Gaberščik A. 1986. Fagopyrum 6: 6-8.

ŽLAHTNJENJE DETERMINANTNE AJDE

Izvleček

S pomočjo končne rasti pri ajdi lahko uravnavamo rast in razvoj ajde. To je lahko osnova žlahtnjenja visokorodne ajde. Večje razraščanje ajde s končno rastjo lahko omejimo z večjo gostoto posevka. Večja gostota posevka pri ajdi s končno rastjo je lahko eden od pomembnih dejavnikov za doseganje visokih pridelkov. Z večjo gostoto rastlin lahko v posevku ajde še povečamo njeno sposobnost za preraščanje večine plevelov.

Fagopyrum 9 (1989): 60-65

Характеристика мутантов гречихи по интенсивности ростовых процессов

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При изучении мутантов большое значение имеет не только их морфологическая характеристика, но и некоторые физиологические показатели. Одним из таких возможных показателей является рост растений, который обеспечивает реализацию генотипа организма в процессе его органогенеза и, как интегральный процесс, является одним из ведущих в реализации наследственной программы организма (Шевелуха, 1987). Изучение процессов роста во временном аспекте позволяет увязать между собой ряд таких показателей, как этапы органогенеза и фазы вгетации, интенсивность ростовых процессов, высоту стебля, которые имеют немало важное селекционное значение.

Цель данной работы: провести сравнительный анализ морфологически различных мутантов гречихи по основным характеристикам динамики роста.

Материал и методы исследований

Из коллекции мутантов были отобраны формы, принадлежащие к различным морфологическим группам (табл. 1). В качестве стандарта использовали районированный сорт гречихи Виктория, который одновременно является и исходным сортом для большинства изучаемых мутантов. В период вегетации проведены замеры высоты стебля. Из второго ряда делянки этикировали 20 случайно взятых растений. Высоту стебля фиксировали по периодам развития растений, начиная с фазы бутонизации и далее: в массовое цветение, разгар цветения, затухание цветения и по достижении спелости (75 %). Полученые данные обрабатывали методами регрессионного анализа (Шмидт, 1984; Зайцев, 1984).

Таблица 1

Краткая характеристика мутантов гречихи

Номер мутанта по каталогу К-ПСХИ	Морфологические особенности
St	Районированный сорт Виктория
05	Карлик типа Надежда (развитые узлы)
0221	Карлик типа Малыш (редуцированные узлы)
0383	Гигант
0427	Детерминант
0302	Короткостебельный
0396	Хлорофильная мутация типа viridis

Результаты и обсуждение

Общеизвестным является тот факт, что рост живых организмов подчиняется ходу S-образных (сигмоидных) кривых: вначале рост идет медленно, затем ускоряется, достигает максимальной скорости, затем замедляется и останавливается. Существует несколько типов кривых роста, которые объединены в один обобщеный класс функций роста (Шмидт, 1984). Формула обобщенной функции роста имеет вид:

$$У = А\ (1 - e^{а + вх}\ /К)^{K}$$

где А, а, в, К – коэффициенты. При различных значениях К функция принимает определенный конкретный вид, которым можно описать рост объекта. Тип кривой (и значение К) определяется по эмпирическим данным. Полученные в нашем опыте данные высоты стебля растения в различные фазы (табл. 2), позволили построить эмпирический график динамики роста мутантов, согласно которому значение К в формуле обобщенной функции роста следует принять равным-1 и формула приобретает вид логистической функции:

Таблица 2

Фактические данные динамики роста стебля мутантов гречихи

Номер мутанта по кат. К-ПСХИ	Фазы вегетации				
	бутонизац.	масс. цв.	разг. цвет.	затух. цв.	созрев.
St	22 / 13,2	36 / 47,7	46 / 89,5	63 / 107,5	78 / 113,0
05	23 / 49,0	37 / 22,7	51 / 43,2	64 / 48,7	79 / 51,2
0383	37 / 42,3	59 / 120,0	73 / 151,2	88 / 168,3	105 / 173,3
0221	23 / 5,0	37 / 11,4	56 / 15,0	66 / 18,4	79 / 19,5
0427	18 / 16,3	32 / 44,0	46 / 68,5	63 / 74,0	77 / 80,2
0302	22 / 12,4	35 / 36,9	45 / 66,3	62 / 79,6	73 / 87,3
0396	23 / 11,2	38 / 31,6	52 / 70,0	72 / 113,4	82 / 119,6

Примечание: в числителе-число дней от всходов, в знаменателе-высота стебля.

$$У = (А : 1 + e^{а + вх}$$

где: А-расстояние между асимптотами (в нашем случае окончательная высота стебля), а и в – константы, определяющие наклон, изгиб и точку перегиба кривой.

Проведенный логистический анализ позволил вычислить для всех изучавшихся мутантов коэффициенты и ошибку уравнения, а так же коэффициент корреляции между эмпирическими и теоретическими значениями высоты стебля по датам промеров (табл. 3).

Как видно из таблицы 3, корреляция между эмпирическими и теоретическими значениями высоты растений велика настолько, что зависимость. практически функциональна: это дает нам основание при анализе роста изучавшихся мутантов использовать теоретические кривые (рис. 1).

Анализ логистической функции роста складывается из определения трех критических точек роста, продолжительности критического периода роста и построения графиков скорости роста и ускорения скорости роста (Шмидт, 1984). Исходя из коэффициентов уравнения логистической функции (табл. 3) и кривых скорости роста (рис. 1) находим координаты точек перегиба кривой и продолжительность основной фазы роста (Ф) (табл. 4), а так же расчитываем скорость роста (рис. 2) и ускорение скорости роста (рис. 3) мутантов.

Таблица 3

Коэффициенты и ошибка уравнения логистической функции; корреляция между эмпирическими и теоретическими значениями роста мутантов гречихи.

Номер мутанта по кат. К-ПСХИ	Коэффициенты ур-я					
	A	a	в	$м_{y-x}$	$R_{y/y'} \pm м_R$	t_R
St	113,1	5,766	−0,154	4,071	0,998 ± 0,031	31,99
05	51,3	5,703	−0,145	1,293	0,999 ± 0,020	50,38
0221	19,6	3,837	−0,109	1,416	0,992 ± 0,075	13,22
0383	173,4	6,159	−0,120	13,825	0,996 ± 0,054	18,50
0427	80,3	3,852	−0,123	4,355	0,997 ± 0,041	24,10
0302	87,4	5,574	−0,152	5,281	0,997 ± 0,046	21,61
0396	119,7	6,415	−0,146	16,645	0,980 ± 0,116	8,46

$t_{05} = 3,18$

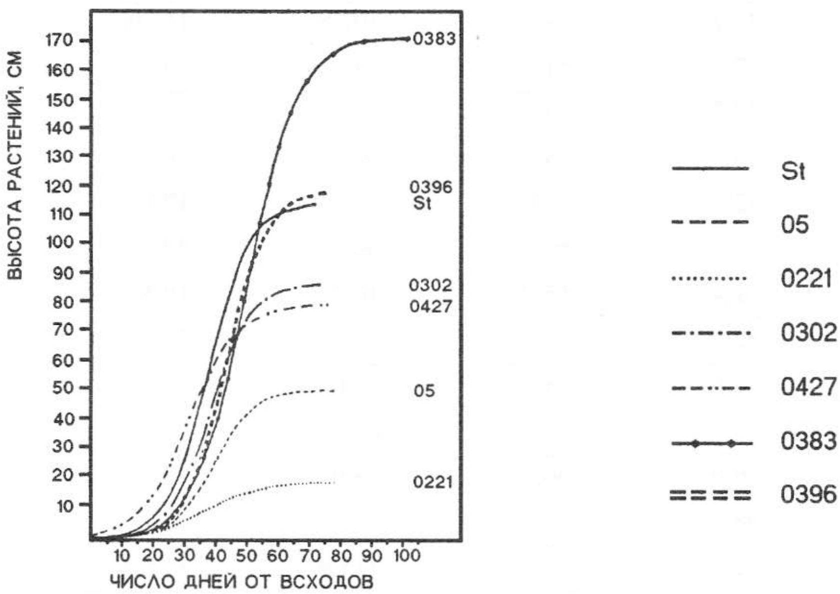

Рис. 1 Кривые роста мутантов гречихи.

Fig. 1. Plant height for cv. Victoria (standard) and mutants in days from germination

Как видно из графика (рис. 1) динамики роста, все изучавшиеся мутанты различны между собой, как по конечной высоте стебля, так и по характеру хода кривых роста. Более пологие кривые у карликов (0221 и 05), близки между собой по наклону кривые роста Виктории, гиганта (0383), формы viridis и низкорослого мутанта (0302). На начальном этапе роста кривая детерминантной формы (0427) имеет некоторые отличия от изучаемых мутантов.

Первый критический возраст (точка T_1, табл. 4), при котором стебель имеет максимальное ускорение скорости роста (рис. 3), наступает у мутантов в разное время. Так у сорта Виктория и низкорослого мутанта первая критическая точка роста наступает почти одновременно, однако максимальное ускоение при этом различно. Детерминант (0427) характеризуется самым ранним вступлением в первую критическую точку и самым меньшим ускорением (0,62 см/сут^2). А у гиганта эта точка наступает позже всех (через 40 дней после всходов), при максимальном ускорении в этот момент 1,27 см/сут^2. Самым высоким ускорением в первую критическую точку отличается сорт Виктория (1,37 см/сут^2), к ней приближается форма viridis (1,3 см/сут^2) хотя период вступления в критическую точку роста у них имеет значительное различие – 28 и 35 дней соответственно. Следует отметить тот факт, что у карлика типа Малыш, гиганта и детерминанта время наступления первой критической точки роста практически совпадает с фазой бутонизации, тогда как у остальных форм эта фаза наступает на 6 . . . 10 дней раньше. Это указывает на то, что большинство изучаемых мутантов начинает бутонизировать в фазу увеличения скорости роста (от начала роста и до достижения первой критической точки), а у морфологически контрастных форм бутонизация наступает только по достижении максимального ускорения роста.

Наиболее важной для растения является вторая фаза роста (от T_1 до T_3), в которой скорость роста является максимальной, а ускорение меняется от максимального до минимального (рис. 2, 3). Переломным моментом роста в этой фазе является вторая критическая точка T_2. в этой точке скорость роста стебля является максимальной, а ускорение равно нулю (рис. 2, 3). Продолжительность этои фазы у мутантов колеблется от 17 (Виктория и низкорослая форма) до 24 дней (гигант). Наибольшая скорость роста отмечена у гиганта (0383) – 1,23 см/сут.

Таблица 4

Анализ логистической функции роста мутантов гречихи.

Номер мутанта по каталогу К-ПСХИ	Точки перегиба						Ф
	Нижняя (T_1)		Средняя (T_2)		Верхняя (T_3)		
	Х	У	Х	У	Х	У	
St	28,8	23,9	37,4	56,6	45,9	89,2	17
05	30,2	10,8	39,3	25,6	48,3	40,5	18
0221	23,2	4,1	35,3	9,8	47,4	15,5	24
0383	40,4	36,6	51,4	86,7	62,4	136,8	22
0427	20,6	17,0	31,4	40,2	42,1	63,3	22
0302	28,0	18,5	36,7	43,7	45,4	68,9	17
0396	34,8	25,3	43,8	59,8	52,8	94,4	18

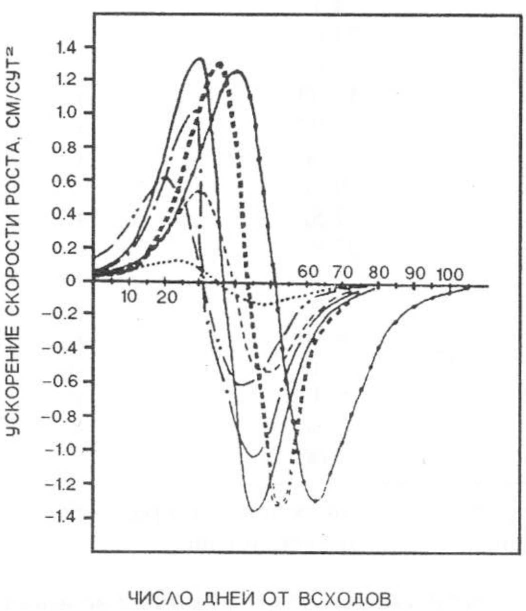

Рис. 2 Кривые скорости роста мутантов гречихи. Обозначения те же, что и на рис. I

Fig. 2. Speed of growth in days from germination

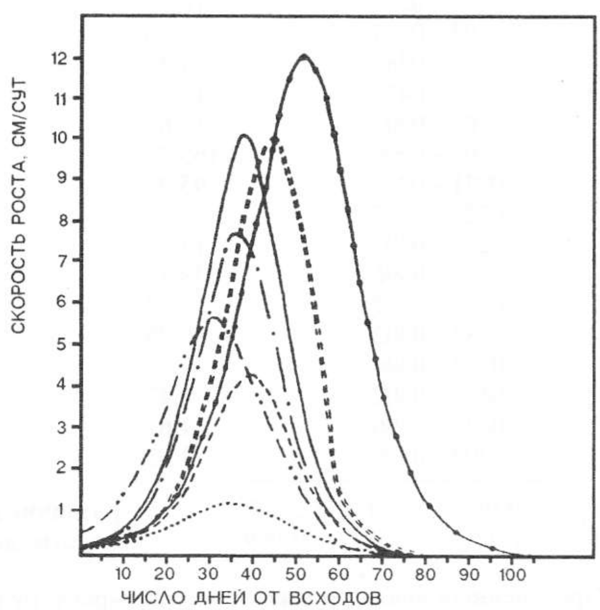

Рис. 3 Кривые ускорения скорости роста мутантов гречихи.

Обозначения те же, что и на рис. I

Fig. 3. Acceleration of growth in days from germination

Координата (X) второй критической точки у всех мутантов практически совпадает с массовым цветением за исключением гиганта (0383) и формы viridis (0396), у которых массовое цветение наступает на 5 . . . 10 дней раньше достижения максимальной скорости роста.

В третьей критической точке (T_3) наступает фаза уменьшения скорости и увеличения ускорения от максимальных отрицательных ускорений до нуля, т.е. начиная с этой фазы происходит прекращение роста растения. Практически эта фаза совпадает с моментом разгара цветения (у Виктории, карлика Надежда, низкорослой формы и формы viridis) или начинается на 4 . . . 9 дней раньше наступления разгара цветения и только у гиганта (0383) наступает позже на 6 дней. Можно отметить, что у большинства мутантов основная фаза роста приходится на межфазный период бутонизация – массовое цветение, хотя по характеру роста мутанты весьма различаются между собой.

В формуле логистической функции роста показатель степени е представляет собой уравнение линейной регресси, что дало нам возможность математически сравнить мутанты между собой методом сравнения двух уравнений линейной регресси (Зайцев, 1984), по их коэффициентам и вычислить достоверность сходства и различия между ними. Этим методом сравниваются ошибки уравнения (критерий F), коэффициенты а и в (критерий t_1 и t_2). Достоверным считается различие, если хотя бы один из критериев превышает табличное значение на самом высоком уровне значимости, а сходство – если все три критерия меньше табличных на самом низком уровне значимости.

Таблица 5

Сравнение коэффициентов уравнения логистической функции роста мутантов гречихи

Сравниваемые формы	Критерии сравн. F	t_1	t_2	Анализ сравнения
St – 05	9,91	0,65	26,33	+
St – 0221	8,27	19,71	35,74	+
St – 0383	11,53	1,30	11,39	+
St – 0427	1,14	14,62	3,39	+
St – 0302	1,68	1,62	2,92	?
St – 0396	16,72	1,74	4,15	?
05 – 0221	1,20	42,79	23,09	+
05 – 0383	114,32	1,57	4,62	?
05 – 0427	11,34	18,52	19,33	+
05 – 0302	16,68	1,00	17,02	+
05 – 0396	165,72	1,96	2,56	+
0221 – 0383	95,32	7,96	0,70	+
0221 – 0427	9,46	0,16	27,52	+
0221 – 0302	13,91	13,46	23,80	+
0221 – 0396	138,18	7,09	5,57	+
0383 – 0427	10,08	7,89	7,35	+
0383 – 0302	6,85	1,80	9,60	+
0383 – 0396	1,45	0,59	5,47	?
0427 – 0302	1,47	10,99	0,33	+
0427 – 0396	14,61	7,10	2,50	+
0302 – 0396	9,93	2,12	3,00	?

F_{05} = 9,98 t_{05} = 2,447 + различие достоверно ? ни сходство ни различие
F_{001} = 141,1 t_{001} = 9,959 – сходство достоверно не установлено

Проведенный анализ показал, что по характеру ростовых процессов стандарт Виктория не имеет сходства с мутантами (табл. 5). Не обнаружено так же сходство и между изучаемыми мутантами. Однако выявлена и весьма парадоксальная особенность некоторых сравниваемых пар, т.е. достоверно не установлено ни сходство ни различие между ними. Видимо такие формы можно отнести к разряду нейтральных. Так, например, по отношению к сорту Виктория у низкорослой и viridis форм наблюдается нейтральное проявление по характеру ростовых процессов. Такую же реакцию по отношению друг к другу можно наблюдать и у некоторых мутантов (гигант и viridis).

Частота нейтрального проявления по показателям роста самая высокая у хлорофильного мутанта типа viridis (табл. 5). В трех из пяти выявленых случаях нейтрального действия участвует форма viridis.

Выводы.

Из вышеизложенного вытекает следующее:

1. Ростовые процессы изучавшихся мутантов по своему характеру подчиняются логистической зависимости, однако большинство мутантов достоверно различаются между собой.
2. Общим для всех мутантов является то, что интенсивный рост начинается в фазу бутонизации, а фаза максимального роста протекает от бутонизации до массового цветения, т.е. наступление каждой фенофазы определяется скоростью роста и ускорением скорости роста.
3. Три критические точки роста у мутантов совпадают с основными фенофазами: бутонизация, массовое цветение, разгар цветения.
4. По характеру ростовых процессов у изучаемых форм не установлено сходства, однако выявлены отдельные пары, у которых достоверно не обнаружено ни сходства ни различия. Такие формы можно отнести к разряду нейтральных.

Литература

1. Зайцев Г. Н. Математическая статистика в экспериментальной ботанике. М., Наука, 1984, 424 с.
2. Шевелуха В. С. Рост, как показатель адаптивных возможностей растений и посевов и использование его характеристик в селекции и растениеводстве. //Регуляция адаптивных реакций сельскохозяйственных растений. Кишинев, 1987, С. 3-11.
3. Шмидт В. М. Математические методы в ботанике. Л., 1984, 286 с.

Резюме

Проведен анализ шести мутантных форм из коллекции мутантов гречихи в сравнении с сортом Виктория по интенсивности ростовых процессов. Установлено, что рост мутантов гречихи подчиняется логистической зависимости. По характеру ростовых процессов большинство мутантов достоверно различаются между собой. Общим для всех изучавшихся мутантов и сорта Виктория является то, что интенсивный рост начинается в фазу бутонизации, а максимальный рост наблюдается от бутонизации до массового цветения. Установлены критические точки роста. Выделены нейтральные по характеру роста мутанты.

STUDIES OF GROWTH OF BUCKWHEAT MUTANTS

Key words: clorophyll mutation, determinate, dwarf, giant, Victoria

Abstract

Growth of buckwheat cv. Victoria and six mutants were studied by mathematical methods in botany according to Schmidt (1984). Height, speed of growth and acceleration of growth were studied in cv. Victoria mutant 05 (dwarf of Nadežda type - developed nodes), 0021 (dwarf of Malish type - reduced nodes), 0383 (giant), 0427 (determinate), 0302 (short stem) and 0396 (clorophyll mutation type *viridis*).

RAZISKAVA RASTI MUTANTOV AJDE

Izvleček

Avtoraj sta raziskovala rast pri ajdi cv. 'Victoria' in šestih mutantih. Proučevani mutanti so bili 05 (pritlikavec tipa Nadežda - razviti nodiji), 0221 (pritlikavec tipa Mališ - reducirani nodiji), 0383 (visoka rast), 0427 (determinantna rast), 0302 (kratkostebelna ajda) in 0396 (klorofilna mutacija tipa *viridis*). Rast je bila analizirina s pomočjo matematičnih metod v botaniki (Schmidt 1984).

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Buckwheat growing in Denmark

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Key words: Introduction, climate, yield, quality, use.

Historically, considerable areas of buckwheat were grown in Denmark. In about 1750, some 30 000 hectares were so planted but from then on the area decreased to almost nothing.

At that time, buckwheat was used for both human beings and animals, as porridge and as green fodder respectively. The buckwheat was dehulled at the farms on a stone grinding mill.

Also at that time, yields were very small and there was great waste because of the poor quality of cultivars.

After 1900, because of changing food habits, buckwheat was grown only on very small areas. Between 1935 and 1986, only a few areas were sown with buckwheat, mainly as animal fodder.

In 1986, buckwheat was again introduced in Denmark as an alternative crop. Mr. Steen Blicher, Dalkildegaard, Faaborg, Denmark grew some hectares of buckwheat at his own farm.

In co-operation with Prof. Bjørn O. Eggum, National Institute of Animal Science, Animal Physiology and Biochemistry, Denmark and Prof. Ivan Kreft, Biotehniška fakulteta, Univerza E. Kardelja, 61001 Ljubljana, Yugoslavia, on the basis of some research and experience it was concluded that buckwheat had possibilities as a future ingredient in the food industry, and an alternative for Danish farmers. Ivan Kreft and his coworkers contributed to the reintroduction of buckwheat to Denmark.

Growing: EUFAGO DANMARK A/S, in co-operation with the Yugoslav scientists has maintained some research in Denmark. State Research Stations and the Danish Agricultural Advisory Centre, Århus, in co-operation with EUFAGO DANMARK A/S, have undertaken research which has strengthened the interest in buckwheat, and contributed information which has resulted in the successful growing of buckwheat.

Buckwheat is grown on a light soil, but has also given good yields on heavier soil.

The buckwheat is only grown on the basis of contracts; the farmers buy new buckwheat seed every year, and are under an obligation to deliver the buckwheat yield to EUFAGO DANMARK A/S.

Climate: We have found that buckwheat can give very good yields, the quality of the Danish grown buckwheat is also very fine. Denmark is on the northern frontier but there are nevertheless adequate possibilities. The buckwheat is mainly sown late in May, but in a few places at the beginning of June. Buckwheat is harvested about August 25.

Yield: The buckwheat yield depends very much on a well-prepared bed and good growth conditions, which are provided by proper instruction to the farmers. Many farmers also have the opportunity for watering at the appropriate stage of growth. Yields are very variable. We have measured yields up to 2.800 kg/hectare. Some cultivars in the experiments also gave over 2.500 kg/hectare.

Table 1: Percentage of hulls in some buckwheat cultivars grown in Denmark.

Cultivar	Ploidy level	1987	1988
SIVA	diploid	17.09 %	15.25 %
DARJA	diploid	13.95 %	11.60 %
HRUSZOWSKA	diploid	19.13 %	16.12 %
EMKA	tetraploid	22.22 %	19.63 %

Quality: The Danish grown buckwheat is of a very fine quality. After dehulling, there is a nice light green buckwheat grain.

It is important here to provide farmers with proper information because the harvest, the drying and the storage have to take place under good conditions.

The authorities have established aflatoxins in some imported buckwheat shipments but they have not been found in Danish grown buckwheat.

Application: Danish grown buckwheat is used in certain new food products which are manufactured and sold in Denmark.

In recent years there have been considerable changes in food habits. Consumers are very aware and want food products of the highest biological and other quality.

Figure 1: Buckwheat fields (x) in Denmark 1988. Average 5.7 ha on each farm, average yield in 1988 1.350 kg/ha.

PRIDELOVANJE AJDE NA DANSKEM

Izvleček

V preteklosti so na Danskem pridelovali veliko ajde. Okoli l. 1750 je bila ajda posejana na 30 000 ha, kasneje se je pridelovanje zelo zmanjšalo; v začetku tega stoletja so le še redki kmetje sejali ajdo. L. 1986 je ajdo začel ponovno pridelovati Steen Blicher na kmetiji Dalkildegaard pri Faaborgu. To je potekalo v sodelovanju s prof. B.O. Eggumom z Danskega državnega inštituta za živinorejo, fiziologijo živali in biokemijo, ter s sodelavci Biotehniške fakultete E. Kardelja v Ljubljani. Sedaj prideluje ajdo večje število kmetov (povprečno 5.7 ha na kmetijo in s povprečnim hektarskim pridelkom 1.35 tone) Ajdo pridelujejo pogodbeno s podjetjem Eufago Danmark A/S, od katerega kmetje kupijo vsako leto seme in kateremu so po pogodbi dolžni prodati ves pridelek ajde. Na Danskem sejejo ajdo konec maja, ponekod v začetku junija, žetev pa je okoli 25. avgusta.

Rekorden pridelek je do 2.8 t/ha, v poskusih pa je več kultivarjev dalo pridelke okoli 2.5 t/ha. Danski pridelek ajde je izredno kakovosten, po luščenju dobimo kašo lepe svetlozelene barve. Medtem ko so oblasti ugotovile pri nekaterih uvoženih pošiljkah ajde aflatoksine, so bili domači pridelki ajde brez njih.

Razvili so nekatere nove izdelke iz ajde, ki jih na Danskem uspešno prodajajo.

Fagopyrum 9 (1989): 68-70

Leaf composition in some buckwheat cultivars (*Fagopyrum* Gaertn.) grown in Kashmir*

Sikandar Farooq and Inayatullah Tahir
Department of Botany, University of Kashmir, Srinagar-190006, India

Key words: buckwheat, chemical composition

Abstract

A comparative study of the leaf composition has been made in the four species of *Fagopyrum* viz. *F. esculentum* Moench, *F. sagittatum* Gilib., *F. tataricum* Gaertn. and *F. kashmirianum* Munshi. *F. esculentum* which possesses thicker and more succulent leaves has a higher content of total sugars and starch, besides a relatively lower phenolic content. F. esculentum is thus more suited as a green vegetable compared to the other three species.

Table 1. Leaf composition (percent fresh weight) at six weeks growth in four species of *Fagopyrum*.

Parameters	*F. escul.*	*F. sagitt.*	*F. kash.*	*F. tatar.*	LSD-P0.05
Alcohol insoluble solids	10.91	13.37	13.56	12.81	0.69
Alcohol soluble solids	2.73	3.31	3.23	2.83	0.37
Total solids	13.65	16.68	16.79	15.64	0.62
Total sugars	1.00	1.05	0.87	0.77	0.03
Starch	0.60	0.44	0.58	0.48	0.05
Phenolics	0.58	0.96	0.81	0.47	0.12
Alcohol soluble nitrogen	0.039	0.045	0.054	0.054	0.015
Alcohol insoluble nitrogen	0.34	0.46	0.54	0.50	0.06
Total nitrogen	0.379	0.505	0.594	0.554	0.06
Total free amino acids as α-amino N	0.024	0.032	0.032	0.030	0.003

Introduction

Among the pseudocereals, buckwheats (Fagopyrum spp., Fam. Polygonaceae) are economically important primarily due to their carbohydrate and protein rich grains, hardiness of plants, short growth span; besides foliage being used as a green vegetable and as an

* The paper was first published in Fagopyrum 8 (1988), p. 27-28, but by mistake in page setting, a part of the paper was omitted.

important commercial source of the glycoside rutin used in medicine (Tahir and Farooq 1983 and 1985, Narain 1983, Marshall 1969). Four species of *Fagopyrum* viz. *F. esculentum* Moench, *F. sagittatum* Gilib., *F. tataricum* Gaertn. and *F. kashmirianum* Munshi have been reported to grow in mixed stands at various high altitude areas of Kashmir (Tahir and Farooq 1983), where constraints of adverse climatic conditions permit the cultivation of short duration crops only such as buckwheat. The present study was aimed at studying the leaf composition in the four species of *Fagopyrum*.

Materials and methods

Fully expanded leaves were collected at 6 weeks growth from the plants of the four species of *Fagopyrum* viz. *F. esculentum* , *F. sagittatum* , *F. tataricum* and *F. kashmirianum* growing in field under identical conditions standardized for optimal growth and yield (Farooq and Tahir 1987). 10 g leaf tissue fixed in hot 80% ethanol was separated into alcohol soluble and insoluble fractions. Alcohol soluble material was used for the determination of alcohol soluble solids, total sugars, alcohol soluble nitrogen, α-amino nitrogen and phenolics. Total sugars were estimated as reducing sugars by the method of Nelson (1944) after enzymatic conversion of non reducing sugars to reducing sugars with invertase. Total free amino acids were estimated as α-amino nitrogen according to the method of Rosen (1957). Phenolics were estimated by the method of Swain and Hillis (1959). Starch was estimated by AOAC method (Horwitz 1965). Nitrogen was estimated by micro-Kjeldahl method. Each presented value is a mean of 4 independent replicates and LSD between species has been computed at P0.05.

Results and discussion

The results of the leaf composition are presented in Table 1. The content of alcohol soluble solids, insoluble solids as also of total solids was less in the leaves of *F. esculentum* than in the other three species. The leaves of *F. esculentum* and *F. sagittatum* contained a higher concentration of total sugars than *F. kashmirianum* and *F. tataricum*. The leaves of *F. esculentum* contained a higher starch content than the other three species. *F. esculentum* and *F. tataricum* contained a lower phenolic content in leaves than *F. sagittatum* and *F. kashmirianum*. The concentration of alcohol soluble nitrogen as also that of total free amino nitrogen was lower in *F. esculentum* than in the other three species. The concentration of alcohol insoluble nitrogen was higher in the leaves of *F. kashmirianum* and *F. tataricum* than in *F. esculentum* and *F. sagittatum*.

Thus a comparative study of the leaf composition in the four buckwheats showed that *F. esculentum* which possessed thicker and more succulent leaves (unpublished results of the authors) has a higher content of total sugars and starch, besides a relatively lower phenolic content. The present findings thus suggest that *F. esculentum* is more suited as a green vegetable compared to the other three species.

References

Farooq S. and Tahir I. 1987. Comparative study of some growth attributes in buckwheats (*Fagopyrum* sp.) cultivated in Kashmir. Fagopyrum 7: 9-12.

Horwitz W. 1965. Official Methods of Analysis of the Association of Official Agricultural Chemists. Association of Official Agricultural Chemists, Washington DC, p. 334-335.

Marshall H.G. 1969. Description and culture of buckwheat. Pennsylvania State Univ. Agr. Exp. Station Bull. 754: 1-26.

Narain P. 1983. Buckwheat in India. Fagopyrum 3: 7-11.

Nelson N. 1944. Photometric adaptation of Somogyi's method for determination of glucose. J. Biol. Chem. 153: 375.

Rosen H. 1957. A modified ninhydrin colorimetric analysis of amino acids. Arch. Biochem. Biophys. 67: 10-15.

Swain T. and Hillis W.E. 1959. The phenolic constituents of *Prunus domestica*. 1. The quantitative analysis of phenolic constituents. J. Sci. Food Agric. 10: 63-68
Tahir I. and Farooq S. 1983. Growth and yield characteristics of some buckwheats (*Fagopyrum* Gaertn.) from Kashmir. Geobios 10: 193-197
Tahir I. and Farooq S. 1985. Grain composition in some buckwheat cultivars (*Fagopyrum* spp.) with particular reference to protein fractions. Qual. Plant. Plant Foods Hum. Nutr. 35: 153-158

KEMIČNA SESTAVA LISTOV PRI NEKATERIH KULTIVARJIH AJDE (*FAGOPYRUM* Gaertn.) V KAŠMIRJU

Izvleček

Primerjana je kemična sestava listov štirih kultivarjev ajde: *Fagopyrum esculentum* Moench, *F. sagittatum* Gilib., *F. tataricum* Gaertn. in *F. kashmirianum* Munshi. Navadna ajda (*F. esculentum*) ima debelejše liste, več skupnega sladkorja in škroba ter relativno malo fenolov. Navadna ajda je zato bolj primerna za zelenjavo kot ostale raziskane ajde (tatarska in druge ajde).

ERRATA - POPRAVKI

In the paper "Review article on buckwheat" by I. Tahir and S. Farooq (Fagopyrum 8, 1988) the last paragraph on p. 42 and continued on p. 44, is correctly read:

Buckwheat seedlings showed greater synthesis of rutin when fed with various sugars (Margna *et al.* 1972a). Glucose fed into isolated buckwheat cotyledons caused an increase in the content of rutin, vitexin, saponaretin and homo-orientin (Margna *et al.* 1974). In excised hypocotyls and cotyledons the accumulation of leucoanthocyanidins was stimulated by glucose and phenylalanine (Margna *et al.* 1972b).

In the paper of Adachi *et al.* (Fagopyrum 8, 1988) in the Table 1 instead of blanc spaces read ".

V članku (in the paper of) L. I. Dovženko (Fagopyrum 8, 1988):

str. (page)	vrsta (line)	namesto (instead of)	prav (read)
64	9	issledovani	issledovanija
"	27	otnogeneza	ontogeneza
66	23	20%	29%
"	31	3-7	3-6
"	38	7	6
67	4	mešoz	mejoz
68	18	bili	bilo
"	29	om	ot
69	3	corr.: subpopuljacii, četko različajušiesja	
71		Fig. 5A horiz. corr.: 5 10 15 20 25 30	
76		Fig. 10 horiz. corr.: 40 80 120 160 200 240 280 320 360 seed number per a plant	
77	Lit. 4.	63	53
"	Lit. 8.	1955	1944
"	Lit. 10.	No. 6	No. 2
78	31	on variety on	variety

INFORMATIONS AND BIBLIOGRAPHY

Population genetics of cultivated common buckwheat, *Fagopyrum esculentum* Moench. VII. Allozyme variability in Japan, Korea, and China

Ohmi Ohnishi
Laboratory of Genetics, Faculty of Agriculture, Kyoto University, Kyoto 606

From: The Japanese Journal of Genetics, Vol. 63 (1988), No. 6, 507-522.

Allozyme variability at 19 loci affecting 12 enzymes were analyzed electrphoretically in 24 Japanese, 3 Korean, and 16 Chinese populations of common buckwheat. Most of the populations were polymorphic at 8 loci, Adh, Dia-2, Got-2, Mdh-1, Mdh-3, 6-Pgdh-1, Pgm-2, and Sdh-1. The percentage of polymorphic loci was 31.6-42.1% and the average heterozygosity was in the range of 0.110-0.138. The level of variability was almost the same as that found in Nepal and India, and was slightly higher than the average of other outbreeding plant species. The allelic frequencies did not vary much among the populations studied, although the Chinese populations had slightly more genetic variability than the Japanese and Korean populations. The present results together with those for the Indian and Nepali populations (Ohnishi and Nishimoto, 1988) led to the following conclusions. The allelic frequencies at the polymorphic loci did not vary much among Asian populations extending from Nepal to Japan; geographical differentiation of allozyme frequencies, due mostly to the loss of alleles, has occured only at the margins of the distribution, such as in the Kumaun and Garwhal hills and in Kashmir in India. This rather unexpected uniformity of allelic frequencies seems to be due to large population size, panmixis within populations, and gene flow between populations, conforming to the theoretical models of Maruyama (1971) and Kimura and Maruyama (1971). Buckwheat does not have a strict center of genetic diversity, but the highest within-population variability was found in the region from southern China to Nepal. Based on the observed minor differences in allozyme frequencies between populations, possible processes of the spreading of buckwheat cultivation in Asia are discussed.

Lipid content and fatty acid composition of buckwheat seed

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From: Cereal Chem. 65 (2) (1988): 122-126.

Dehulled seed of the three most important North American cultivars of buckwheat, Mancan, Tokyo, and Manor, were analyzed for content of total, free, neutral, glyco-, and phospholipids, and each class of lipid was analyzed for fatty acid composition. The samples contained from 2.6±0.2 to 3.2±0.1% total lipids of which 81-85% were neutral lipids, 8-11% phospholipids, and 3-5% glycolipids. Free lipids, extracted in petroleum ether, ranged from 2.1±0.1 to 2.6±0.1%. The major fatty acids of all cultivars and of all classes of lipids were palmitic (16:0), oleic (18:1), and linoleic (18:2) acid. Average values of these three fatty acids in the total lipids of all buckwheat samples examined were 14.0±0.8, 36.3±1.9 and 37.0±1.9%, respectively. The corresponding values for the free lipids were 14.8±1.5, 36.5±2.0, and 35.5±1.9% and those for phospholipids were 9.1±0.8, 44.3±4.4, and 41.7±2.8%, respectively. Total lipid content showed significant positive correlation with free, neutral, and glycolipid contents, and there was a highly significant negative correlation between oleic and linoleic acid contents of all lipid classes. There was, however, no statistical difference between new and old buckwheat in the content of free, neutral, glyco-, and phospholipids and in the fatty acid composition of total and free lipids.

The Book of Soba
James Udesky

The Book of Soba is the first book in English to fully explore this long-cherished food tradition, and James Udesky, the first Westerner to complete a soba apprenticeship. He examines the soba culture in depth and offers the latest assessment of the nutritional value of this healthy, lysine-rich, fat-free pasta.

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First printing, 1988. ISBN 0-87011-860-9 (U.S.). ISBN 4-7700-1360-4 (Japan). USD 14.95

Breeding systems in buckwheat (*Fagopyrum* spp.) cultivated in Kashmir
I. Tahir and S. Farooq
Department of Botany, University of Kashmir, Srinagar - 190006, Kashmir, India
From: Genetika, Vol. 19 (1987), No. 3, 205-208.

A comparative study has been made of the breeding system in the four buckwheats viz. *F. esculentum* Moench, *F. sagittatum* Gilib., *F. tataricum* Gaertn. and *F. kashmirianum* Munshi. *F. esculentum*, besides being predominantly heterostylous, shows dimorphism of pollen grains and stigmas compared to the other three species which are predominantly heterostylous. The effective pollination in *F. esculentum* is largely entomophylous in contrast to the other three species. In *F. esculentum* seed set in open pollinated inflorescences was markedly higher than in bagged inflorescences whereas, no appreciable difference was recorded in the seed set between open pollinated and bagged inflorescences for the other three species. This substantiates the assumption that *F. esculentum* is essentially self incompatible whereas, the other three species are self compatible.

Some results of important morphological and biological characteristics of buckwheat
Miroslav Bogdanović
Faculty of Agriculture, Sarajevo, Yugoslavia
From: Radovi Poljoprivrednog fakulteta, Vol. XXXV (1986), No. 38, 35-47.

During three-year investigations, the influence of genotype, variety, sowing time and mineral fertilizers doses on morphological and biological, productive and qualitative characteristics of buckwheat were examined.

The results of this investigation show important morphological and biological characteristics of buckwheat.

The height of the plants was mostly influenced by the weather conditions, genetic characteristics of the species and mineral fertilizers doses.

The number of leaves depended on the height of a plant and shooting into branches.

The leaf area mostly depended on the number of leaves formed on the plant and species characteristics.

The number of florescences is in the positive correlation between a number of the branches and genetic characteristics of the variety.

The number of grains formed on the plant depended on the weather conditions during the phase of fertilizing of the plant, numbers of florescences formed and of insect pollination.

The percentage of filled grains mostly depended on temperature conditions, precipitation and incombing of nutrients in the flower.

Genotype, variety, fertilising and sowing time influence on the grain production of buckwheat (*Fagopyrum esculentum* Moench).

Miroslav Bogdanović
Faculty of Agriculture, Sarajevo, Yugoslavia

From: Radovi Poljoprivrednog fakulteta, Vol. XXXV (1987), No. 39, 5-12.

On the basis of the three-year investigations with buckwheat culture, the following can be concluded:

Since there are a lot of diffrences in plant spacing during the germination and during the harvest of different varieties it is important to attain optimal plant stand per area unit.

For the high grain yield of buckwheat, besides the genetic potential for fertility, it is important to obtain desired plant stand per area unit and productivity of the grain per a plant.

Using the mineral fertilizers in buckwheat production proved to be beneficial. The highest grain yield of buckwehat was when the soil was fertilized before sowing at rate of $N_{50}P_{60}K_{60}$ + foliar treatment with boron 3.4 g and urea 6.6 g in 10 liter of water per 150 square meters of the crop at the beginning of flowering.

Sowing periods had important influence on the grain yield of buckwheat of certain varieties. The best sowing time for buckwheat is at the end of May or in the beginning of June in the hillymountain area of Bosnia.

The potential possibility of the grain yield increase is in the reduction of unfilled grains before attention would be paid to this problem in breeding work in buckwheat.

During the three-year investigations the highest grain yield was obtained in denser plant stand for about 30% more, although productivity per plant was lower.

Modelling of net photosynthetic productivity for buckwheat (*Fagopyrum esculentum* Moench)

L. Kajfež-Bogataj and A. Hočevar
Agronomy Department, Edvard Kardelj University of Ljubljana, Yugoslavia

From: Agricultural and Forest Meteorology, 44 (1989) 233-244

The dynamic model BUCKWHEAT simulates the photosynthetic activity of a buckwheat (*Fagopyrum esculentum* Moench) plant canopy. It assumes healthy plants and appropriate nutrition and calculates dry matter production per unit ground area. The basis of the model is the energy balance of the leaf, from which leaf temperature nad energy fluxes are calculated. Net photosynthesis of the leaf is a function of leaf temperature and solar irradiation. This function was verified experimentally. With the model, buckwheat organic mass production was calculated for each day of the growing period (24 July - 7 October 1985), using environmental parameters observed in Ljubljana, and compared with the values observed in the field. Comparisons of observed and calculated production in seccessive time periods, and of cumulative productivity, show close agreement. Applications of the model and possible improvements, are being considered.

Influence of water activity and temperature on dehulling of buckwheat

G. Mazza and C.G. Campbell
Agriculture Canada, Research Station, Morden, Manitoba, ROG 1JO, Canada

From: Cereal Chem. 62 (1985) (1): 31-34.

Dehulling and moisture sorption characteristics of three buckwheat cultivars were determined at water activities of 0.11-0.98 and at 1, 10, 25, and 40°C. The dehulling recovery varied among cultivars and water activities of the seed. Of the three cultivars, Mancan yielded the most groats and CM 169 yielded the least. The dehulling yield of each cultivar decreased as the water activity of the seed increased but was essentially unaffected by temperature. The amount of whole groats in the dehulled fraction was constant at water activities of 0.11-0.50 but more than doubled as the water activity was increased from 0.50 to 0.98. The optimum water activity for minimizing the rate of degradation of buckwheat seed during storage and for maximizing the dehulling yield and percentage of whole groats was approximately 0.18.

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ГЕНЕТИКА ЦВЕТКА и ПРОБЛЕМА СОВМЕСТИМОСТИ У ГРЕЧИХИ

Ответственные редакторы
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Tasmania Soba

TASMANIA
白鳥製粉 SOBA

At the occasion of the first shipment of buckwheat grain from Australia to Japan, in June 1988 was published the booklet Tasmania Soba (in Japanese). Booklet was published by Shiratori Flour Mill Company, Narashino City, Chiba Prefecture, Japan. Buckwheat was introduced in Tasmania by this company and the Department of Agriculture, Tasmania, in cooperation with scientists from Miyazaki University, Japan and Ljubljana University, Yugoslavia. Buckwheat gives in Tasmania good yields of high quality. The idea for this so called 'Southern Cross Project' was, to deliver in April high-quality freshly harvested buckwheat grains from Tasmania to Japan where it is in July and in August the highest demand for buckwheat-soba noodles.

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