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Chemical composition of barley varieties with different nutrient supplies I. Concentration of nitrogen, tannins, phytate, β-glucans and minerals

Bygsorters kemiske sammensætning ved varierende næringsstoftilførsel
I. Koncentration af kvælstof, tannin, phytin, β-glucaner og mineralstoffer

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Summary

21 commercial barley varieties, KVL 468 and Risø 1508 were grown in pots and in the field with increasing nitrogen nutrition.

The concentration of tannins varied from 0.8 to 1.7 g (as catechin) per kg dry weight. The lower concentrations were found in the varieties Aramir, Claudia, Diva and Lofa. In most of the varieties the concentration of tannins varied moderately in relation to the nitrogen nutrition. The concentration of phytate phosphorus varied from 2.2 to 3.5 g per kg of dry matter, and was almost the same for all varieties, however it increased with increasing nitrogen supply. The phytate-P was an almost constant fraction of the total phosphorus.

The concentration of soluble β-glucans was measured by viscosity. The viscosity varied from 1.5 to 5.4 centipoise of acid extract. The varieties Canova, KVL 468 and Risø 1508 had the lowest concentration. The concentration of β-glucans increased with increasing nitrogen supply.

Key words: Barley varieties, tannins, phytate, β-glucans, minerals, nitrogen, nutrition.

Resumé

I kerner fra mark- og karforsøg med 21 bygsorter samt KVL 468 og Risø 1508 tilført stigende mængder kvælstof bestemtes indholdet af N, P, K, Mg, Ca, tannin, phytin og opløselige β-glucaner.

Tanninindholdet varierede fra 0,8 til 1,7 g tannin pr. kg tørstof og var lavest for sorterne Aramir, Claudia, Diva og Lofa. I de fleste sorter var tanninindholdet næsten uafhængigt af kvælstoftilførslen. Indholdet af phytin-P varierede fra 2,2 til 3,5 g pr. kg tørstof. Der var små sortsforskelle, men indholdet steg med stigende kvælstoftilførsel. Phytin-P var næsten en konstant fraktion af total-P – uafhængigt af sort og kvælstoftilførsel. Indholdet af opløseligt β-glucan blev målt ved viskositet. Viskositeten varierede fra 1,5 til 5,4 centipoise, hvor de laveste værdier fremkom for sorterne Canova, KVL 468 og Risø 1508. Kvælstoftilførsel medførte en kraftig stigning i indholdet af β-glucan.

Nøgleord: Bygsorter, tanniner, phytin, β-glucan, mineralstoffer, kvælstof, ernæring.

Introduction

Barley is an important animal fodder. However, the nutritional value may be reduced to some extent by the occurrence of certain components which decrease the nutrient absorption in monogastric animals (4, 8, 11, 13, 18).

Results from previous investigations have shown that the concentration of amide and lysine in barley varied dependent on variety and protein concentration (30). In order to investigate whether a similar situation might occur concerning tannins, phytate, β-glucans and minerals the present investigations were started with 21 barley varieties, KVL 468 and Risø 1508.

As for other monocotyledons the tannins in barley belong to the condensed tannins or proanthocyanidins (3) which are polymer products of catechin units (17).

Tannins as a group of plant phenols react with proteins. This protein bond may inhibit the enzymatic break down of proteins in animals (28) and thereby, to some degree, be the cause of a relatively low digestibility of proteins in monogastric animals (9, 11). Tannins may also render the feed unpalatable.

A phytate is a salt of phytic acid (mesoinosit – hexaphosphoric acid ester). In the barley seed it occurs mainly in the aleurone layer (6). Phytic acid is made up by successive esterification of inositol with phosphoric acid. In animals phytate is difficult to break down, in pigs only about 20 per cent is broken down (25). Phytate may build a strong bond to different multivalent cations, especially zink (23), and deficiencies may arise in animals. Phytate and proteins may also build complexes, which are difficult for the enzymes to break down. The circumstances mentioned are possibly the reason for the rather low absorption in animals of minerals and proteins from barley (4, 23, 25).

The β-glucans are polysaccharides made up of glucose units (26). They are partly soluble in acid media, whereby the viscosity increases (1). Such a sticky media in the stomach of monogastric animals, especially poultry, may result in reduced absorption of the nutrients (12, 13, 19). A strong correlation between the content of soluble β-glucans and the viscosity of barley extract has been found (1).

The β-glucan content has not been consistently influenced by nitrogen nutrition (18) it varies from one site to another (10) it decreases under moist growth conditions and during ripening (2) and it seems to be low in the husk (14).

Materials

In 1979 21 barley varieties, KVL 468 and Risø 1508 were grown in field in loamy sand at Borris and in sandy loam at Tystofte and supplied with 0 (N_0), 60 (N_1), 120 (N_2), 180 (N_3) kg nitrogen per ha. Varieties were also grown in cylindrical PVC-pots with a surface area of 500 sq. cm. The pots contained 19.4 kg of a mixture of sandy soil and neutral silver sand. The experiment was carried out with 20 plants per pot and 2 replications.

As a basic dressing each pot was supplied with 2.25 g P and 5 g K as KH_2PO_4 and K_2HPO_4 and further with 0.5 g Mg as $MgSO_4$, 0.1 g Mn as $MnSO_4$, 0.1 g Cu as $CuSO_4$, 0.01 g B as H_3BO_3, and 10 g $CaSO_4$. Nitrogen was supplied as NH_4NO_3 corresponding to 0.5 (N_0), 2.0 (N_1), 5.0 (N_2), 9.5 (N_3) g nitrogen per pot. Water was supplied daily to the surface by an automatic system bringing the growth medium to field capacity.

During the growth period the plants were sprayed to reduce the attack of aphides and mildew. At harvesting at full maturity the seeds were kept for analysis and ground to 1 mm. The material for phytate and tannin determinations were freeze dried.

Analytical methods

Dry matter dertermination was carried out at 100°C o.n. Total nitrogen was determined by a Kjeldahl method using $CuSO_4$-selenium catalyst (5). Tannin was determined by the method of *Truelsen* (31). Phytate phosphorus was determined by precipitation with $FeNH_4(SO_4)_2$ (24) and phosphorus determination in the precipitate and total phosphorus was determined by the vanadate method. The viscosity was determined

Table 1. Percentage of total nitrogen in dry matter of barley seeds of different varieties.
Procentisk indhold af totalkvælstof i tørstof af bygkerner af forskellige sorter.

Experiment *Forsøg*	Pot *Kar*				Borris				Tystofte			
Treatment *Forsøgsled*	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
Variety *Sort*												
1 Zita	1.34	1.62	2.14	2.89	1.43	1.33	1.67	2.14	1.38	1.56	1.81	2.04
2 Alf	1.21	1.74	2.25	2.99	1.32	1.22	1.49	1.95	1.44	1.50	1.82	2.04
3 Alva	1.19	1.63	2.01	2.57	1.28	1.16	1.41	1.78	1.40	1.40	1.54	1.76
4 Aramir	1.37	1.82	2.22	2.99	1.44	1.28	1.56	2.08	1.56	1.73	1.98	2.26
5 Canova	1.17	1.53	2.01	2.77	1.33	1.21	1.51	2.06	1.42	1.60	1.81	2.16
6 Claudia	1.18	1.63	2.32	3.06	1.31	1.18	1.45	1.84	1.37	1.45	1.70	2.06
7 Diva	1.28	1.69	2.14	3.40	1.38	1.29	1.68	2.20	1.46	1.80	2.16	2.39
8 Duks	1.18	1.55	2.00	2.74	1.37	1.32	1.71	2.17	1.36	1.53	1.91	2.02
9 Georgie	1.29	1.71	2.22	2.81	1.32	1.20	1.46	1.94	1.47	1.50	1.82	1.97
10 Harry	1.26	1.73	2.20	2.98	1.36	1.20	1.49	1.87	1.43	1.60	1.85	2.01
11 KVL 468	1.50	1.93	2.55	3.03	1.78	1.77	2.03	2.52	2.12	2.30	2.55	2.63
12 Lami	1.27	1.63	2.27	3.10	1.36	1.22	1.57	2.07	1.35	1.64	1.86	2.18
13 Lofa	1.21	1.71	2.24	2.94	1.44	1.26	1.52	2.06	1.54	1.71	1.87	2.14
14 Mona	1.46	1.88	2.54	2.90	1.39	1.38	1.61	2.02	1.64	1.78	1.97	2.15
15 Nordal	1.19	1.48	1.76	2.65	1.32	1.20	1.48	1.98	1.37	1.43	1.79	2.01
16 Prisca	1.28	1.73	2.11	2.48	1.53	1.44	1.87	2.35	1.59	1.69	2.10	2.40
17 Proctor	1.25	1.59	2.10	2.80	1.37	1.29	1.48	1.93	1.47	1.67	1.88	1.99
18 Risø 1508	1.37	1.78	2.22	2.87	1.45	1.41	1.72	2.18	1.57	1.84	2.02	2.18
19 Rupal	1.30	1.74	2.14	2.79	1.38	1.33	1.65	2.14	1.50	1.70	2.01	2.27
20 Salka	1.26	1.59	2.04	3.01	1.45	1.35	1.64	1.99	1.42	1.56	1.74	1.98
21 Tron	1.21	1.61	2.19	2.94	1.37	1.22	1.59	2.01	1.51	1.81	2.02	2.20
22 Varunda	1.31	1.67	2.19	2.76	1.42	1.29	1.61	2.05	1.58	1.68	1.77	2.08
23 Vega	1.17	1.57	2.01	2.67	1.35	1.19	1.49	1.93	1.45	1.60	1.78	2.05

by extraction in acid media (15) and using a Haake falling ball viscometer. The relationship between viscosity and β-glucan content is well documented by *Aastrup* (1).

Results

As a whole the yield in pot experiments increased up to N_2 followed by a decrease to N_3 and the grain weight increased from N_0 to N_1 or N_2 and then decreased. For the field experiments the yield increased from N_0 up to N_3.

From the results in Table 1 concerning nitrogen concentration it can be seen that there is a great variation among the varieties, and that the range for the varieties varies from one experiment to another. Even when columns with nearly equal nitrogen per cent, for instance in the pot experiment N_1, Borris N_2, and Tystofte N_1, are compared, the range from the columns is not in agreement with the results published by *Rasmussen* (27) and which are the average of several experiments.

The KVL 468 and Risø 1508 have a high nitrogen concentration, and in the pot experiment Mona exceeds Risø 1508. In the field experiments Diva and Prisca reach high concentrations, but in the pot experiment, Alf, Aramir, Claudia, Diva, Lami and Salka reach the highest concentrations of nitrogen.

A great variation in viscosity from 1.5 up to 5.4 centipoise can be seen from the results in Table 2. It is mainly related to nitrogen nutrition, but among the varieties at a certain nitrogen supply a variation corresponding to a factor of two can be seen. As a whole Aramir, Canova, Duks, Lofa and Nordal and especially KVL 468 and Risø

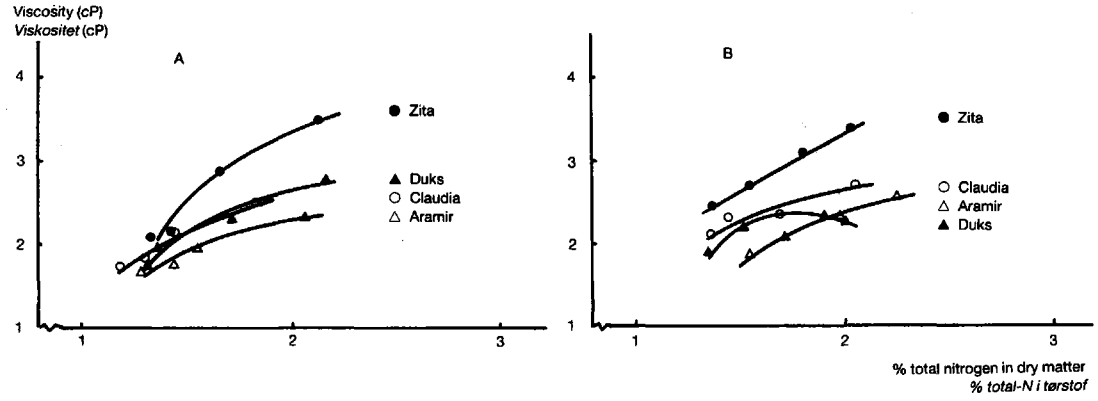

Fig. 1. Viscosities of extracts from barley varieties in relation to nitrogen concentrations. A. Borris and B. Tystofte.
Viskositet af ekstrakter fra bygsorter ved forskellige kvælstofkoncentrationer. A. Borris og B. Tystofte.

Table 2. Viscosity of barley extracts and content of tannins and phytate-P in dry matter of barley seeds (pot experiment).
Viskositet af bygekstrakt og indhold af tannin og phytin-P i tørstof (karforsøg).

Treatment *Forsøgsled*	Viscosity *Viskositet*				Tannins *Tanniner*				Phytate-P *Phytin-P*			
	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
Variety *Sort*	centipoise				g/kg				g/kg			
1 Zita	2.4	3.6	4.2	5.3	1.09	1.13	1.18	1.16	2.4	2.6	2.9	2.9
2 Alf	2.1	3.0	3.7	3.8	1.32	1.34	1.40	1.73	2.6	2.8	3.2	3.3
3 Alva	1.8	2.1	2.7	3.5	1.36	1.28	1.27	1.36	2.5	2.7	2.9	2.9
4 Aramir	1.7	1.9	2.5	3.2	0.95	0.83	0.84	0.88	2.7	2.8	3.0	3.4
5 Canova	1.5	1.6	2.0	2.4	1.15	1.07	1.06	1.07	2.7	2.7	2.9	2.9
6 Claudia	1.8	2.5	3.5	3.7	1.08	1.04	1.09	1.08	2.9	3.0	3.2	3.3
7 Diva	2.0	2.4	3.0	3.1	0.89	0.89	0.97	1.04	2.6	3.0	3.2	3.5
8 Duks	1.7	1.8	2.4	2.8	1.24	1.22	1.41	1.40	2.4	2.5	2.8	3.0
9 Georgie	2.3	2.6	3.3	4.1	1.09	1.10	1.11	1.21	2.6	2.7	2.9	3.1
10 Harry	2.2	2.9	3.7	4.1	1.19	1.08	1.05	1.04	2.3	2.7	2.7	3.0
11 KVL468	1.7	1.9	2.1	2.3	1.63	1.42	1.34	1.27	2.7	3.0	3.1	3.2
12 Lami	3.1	4.3	5.2	5.4	1.28	1.22	1.37	1.33	2.6	2.7	2.9	3.3
13 Lofa	1.6	1.9	2.7	3.2	1.12	1.02	1.01	1.08	2.6	2.8	3.1	3.1
14 Mona	2.2	3.0	3.9	4.4	1.07	1.15	1.29	1.22	2.8	3.1	3.5	3.4
15 Nordal	1.8	2.0	2.8	2.9	1.05	1.05	1.11	1.11	2.4	2.7	2.8	3.0
16 Prisca	1.9	2.4	3.6	4.9	1.15	1.08	1.10	1.11	2.3	2.7	2.9	2.8
17 Proctor	1.5	1.9	3.0	3.9	1.14	1.13	1.14	1.34	2.6	2.6	2.7	2.9
18 Risø 1508	2.0	2.0	2.2	2.2	1.31	1.23	1.26	1.37	2.5	3.2	3.2	3.0
19 Rupal	2.2	2.4	3.6	4.6	1.39	1.34	1.43	1.51	2.5	3.0	3.1	3.1
20 Salka	2.6	3.5	4.3	4.0	1.25	1.23	1.16	1.31	2.5	2.6	3.3	3.3
21 Tron	2.6	3.5	4.3	3.8	1.39	1.47	1.56	1.70	2.6	2.8	3.1	3.3
22 Varunda	2.0	2.3	3.6	4.1	1.23	1.21	1.19	1.26	2.8	3.0	3.3	3.3
23 Vega	1.7	2.1	3.0	3.5	1.30	1.19	1.30	1.35	2.2	2.5	2.6	2.9

1508 show low viscosity compared to Lami, Salka, Tron and Zita, which seem to give an extract with a high viscosity. The increase in viscosity related to nitrogen concentration is small for KVL 468 and Risø 1508.

The results for four varieties from the field experiments are presented in Fig. 1. These results agree rather well with the corresponding results in Table 2.

From the results in Table 2 concerning the concentrations of tannins it can be seen that there are some variations from one variety to another. Rupal and Tron have a rather high content and the concentrations in Aramir and Diva are low. The relation between concentrations of nitrogen and tannins varies from one variety to another and does not give a clear trend. For Alf, Duks, Proctor and Tron the concentrations of tannins are positively related to the concentrations of nitrogen, but for KVL 468 a clear decrease is seen.

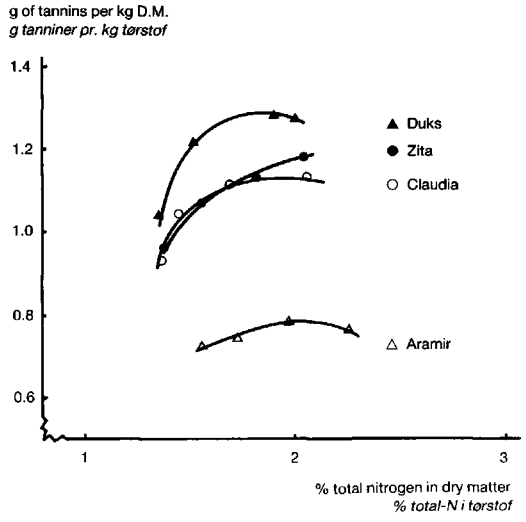

Fig. 2. Tannin contents in seeds of barley varieties in relation to nitrogen concentrations. Tystofte.

Tanninindhold i kerner fra bygsorter ved forskellige kvælstofkoncentrationer. Tystofte.

Table 3. Concentrations of potassium, magnesium and calcium in dry matter of barley seeds (pot experiment).
Koncentrationen af kalium, magnesium og calcium i tørstof af bygkerne (karforsøg).

	Potassium K				Magnesium Mg				Calcium Ca			
Treatment *Forsøgsled*	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
Variety *Sort*	g/kg				g/kg				g/kg			
1 Zita	5.9	5.8	5.3	6.1	1.1	1.1	1.2	1.4	0.49	0.51	0.62	0.74
2 Alf	4.8	5.5	7.1	7.6	1.2	1.2	1.3	1.5	0.51	0.55	0.67	1.00
3 Alva	5.5	4.7	5.4	5.5	1.1	1.2	1.2	1.3	0.46	0.52	0.60	0.74
4 Aramir	4.9	4.2	4.9	5.8	1.2	1.3	1.3	1.5	0.44	0.47	0.53	0.64
5 Canova	5.2	4.7	5.0	5.3	1.2	1.2	1.2	1.4	0.43	0.48	0.53	0.67
6 Claudia	5.1	4.9	6.6	6.4	1.2	1.2	1.3	1.5	0.49	0.52	0.59	0.72
7 Diva	5.1	4.5	5.3	6.4	1.2	1.2	1.3	1.5	0.44	0.49	0.55	0.70
8 Duks	5.5	4.6	6.2	5.9	1.2	1.2	1.3	1.5	0.53	0.61	0.71	0.84
9 Georgie	5.4	4.5	4.9	5.7	1.2	1.3	1.3	1.5	0.47	0.53	0.63	0.78
10 Harry	5.1	4.5	5.2	6.5	1.1	1.2	1.2	1.5	0.40	0.45	0.51	0.69
11 KVL 468	4.9	4.4	4.7	4.9	1.2	1.3	1.4	1.5	0.47	0.56	0.63	0.68
12 Lami	5.5	5.7	5.9	6.1	1.2	1.3	1.3	1.5	0.51	0.56	0.65	0.83
13 Lofa	4.5	4.6	5.8	5.9	1.2	1.3	1.3	1.5	0.50	0.54	0.60	0.66
14 Mona	5.0	4.7	6.4	6.4	1.2	1.3	1.4	1.4	0.46	0.50	0.72	0.74
15 Nordal	5.3	4.6	5.9	6.1	1.1	1.2	1.2	1.5	0.44	0.54	0.60	0.75
16 Prisca	5.1	4.2	5.1	4.9	1.1	1.2	1.1	1.2	0.40	0.51	0.59	0.76
17 Proctor	4.3	4.7	5.2	6.1	1.2	1.2	1.2	1.4	0.42	0.43	0.50	0.64
18 Risø 1508	5.6	4.6	5.6	6.0	1.2	1.3	1.3	1.5	0.49	0.57	0.66	0.83
19 Rupal	5.7	4.4	5.2	5.9	1.2	1.3	1.3	1.5	0.55	0.65	0.72	0.84
20 Salka	5.5	5.5	5.1	6.2	1.1	1.2	1.2	1.4	0.44	0.50	0.55	0.80
21 Tron	5.3	4.9	6.2	6.2	1.2	1.3	1.4	1.6	0.52	0.56	0.69	0.88
22 Varunda	5.6	4.7	5.6	5.8	1.2	1.2	1.2	1.3	0.46	0.50	0.52	0.67
23 Vega	5.4	4.7	5.6	6.0	1.1	1.2	1.1	1.4	0.58	0.64	0.69	0.82

From the curves in Fig. 2 it can be seen that the concentrations of tannins in Claudia, Duks and Zita increase with the concentration of nitrogen as in the pot experiment, and that Aramir has a comparatively low concentration of tannins.

The results for phytate phosphorus, which also are presented in Table 2, show some variation from one variety to another. However, Prisca, Vega and Zita have a fairly low content, while Aramir, Claudia, Diva, Mona and Varunda have a relatively high concentration of phytate-P. For all the varieties the concentration of phytate-P increases with increasing nitrogen content. After determination of total phosphorus it could be ascertained that for all the treatments phytate-P very nearly amounted to 65 per cent of total-P.

The results for concentrations of potassium, magnesium and calcium can be seen from Table 3.

The concentrations of potassium vary up to 50 per cent relatively from one variety to another. The results for some of the varieties (Alva, Canova and Prisca) show an almost constant value independent of nitrogen fertilization, whereas the content in Alf, Claudia, Mona and Proctor increase to a relatively high figure related to the nitrogen concentration. The magnesium content also increases with the nitrogen concen-

Table 4. Concentrations of potassium, magnesium, calcium and phosphorus in dry matter of barley seeds (field experiment).
Koncentrationen af kalium, magnesium, calcium og fosfor i tørstof af bygkerne (markforsøg).

	Borris				Tystofte			
Treatment *Forsøgsled*	N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
Variety *Sort*	g potassium/kg *g K/kg*							
1 Canova	4.8	4.3	4.0	3.8	4.0	3.6	3.6	3.8
2 Mona	4.9	4.6	4.3	4.1	4.3	3.9	3.8	3.7
3 Tron	5.5	5.0	4.8	4.9	4.6	4.1	4.1	4.0
4 Vega	5.8	4.7	4.8	4.7	4.5	4.3	4.2	3.9
	g magnesium/kg *g Mg/kg*							
1 Canova	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2
2 Mona	1.1	1.0	1.0	1.1	1.2	1.1	1.1	1.2
3 Tron	1.2	1.1	1.2	1.2	1.2	1.2	1.2	1.2
4 Vega	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2
	g calcium/kg *g Ca/kg*							
1 Canova	0.38	0.40	0.44	0.46	0.43	0.51	0.61	0.75
2 Mona	0.42	0.42	0.42	0.46	0.47	0.48	0.58	0.64
3 Tron	0.44	0.46	0.50	0.54	0.56	0.62	0.67	0.75
4 Vega	0.44	0.48	0.52	0.56	0.57	0.62	0.70	0.72
	g phosphorus/kg *g P/kg*							
1 Canova	4.2	3.5	3.4	3.5	3.8	3.2	3.1	3.4
2 Mona	4.2	3.7	3.6	3.5	4.2	3.8	3.4	3.4
3 Tron	4.3	3.8	3.5	4.1	4.1	3.7	3.6	3.3
4 Vega	4.1	3.8	3.6	3.4	3.9	3.4	3.4	3.3

tration and the calcium content does so even more. The varieties Alf, Lami, Rupal and Tron with high concentrations of calcium seem to have the largest increase with the nitrogen concentration, whereas Aramir, Proctor and Varunda are on a lower level and the increase with nitrogen concentration is smaller.

From the figures in Table 4 it can be seen, that the magnitude of the results corresponds well to those from the pot experiment, however here the concentrations of potassium and phosphorus decrease with increasing nitrogen application.

Discussion

The nitrogen concentration is highest in grains from the pot experiment and is a little lower for the crop from the loamy sand at Borris than for the crop from the sandy loam at Tystofte.

One of the reasons why higher concentrations of nitrogen are reached in the material from the pot experiment and why another trend in the varieties is found in the field experiments could be a greater interaction between varieties and growth factors for instance the abundant water supply and a higher nutrient supply per unit of area to the crops in the pot experiment.

On the whole the percentage of nitrogen increases with increasing nitrogen supply, however the results from Borris are an exception, the results from N_1 are smaller than those for N_0 and N_2. The cause of this may be that this sandy soil contains less available nitrogen than the two others and the yield curve for this experiment starts on a relatively lower level, the consequence of which results in the pattern of decreasing and then increasing concentration of the nutrient in question as discussed previously (29).

Concerning the viscosity of the extract the variation among the varieties is not related to the concentration of nitrogen characteristic of a certain variety in the present experiment, and neither to some of the other components determined.

To some extent the viscosity is characteristic of the varieties. Canova, Duks, KVL 468 and Risø 1508 have low viscosity and the increase following nitrogen nutrition is fairly small for these varieties, whereas Prisca, Proctor and Rupal have a large increase as a result of nitrogen nutrition. Lami, Salka, Tron and Zita have extracts with rather high viscosity, and this increases considerably with increasing nitrogen application for Lami and Zita but not for Salka and Tron.

In relation to nitrogen application the concentration of tannins mainly decreased from N_0 to N_1 and then increased through N_2 to N_3. To a certain degree this pattern was related to the grain weight, which was higher for N_1, and so the concentration of tannins may be related to the surface area of the grain on a weight base, but then again the thickness of the husks may interfere to some extent. Tannins in Alf and Tron increased considerably when grain weight as a function of nitrogen supply decreased from 43 to 24 and from 43 to 29 respectively. However, Harry had large grains, the weight of which decreased from 60 to 42 but had a decrease in the content of tannins and KVL 468 had a large decrease in the content of tannins but a decrease in grain weight from 40 to 36 only. The magnitude of tannins found here agrees with other findings (7, 20).

For phytate phosphorus the variation among the varieties has been of very much the same magnitude as that following nitrogen nutrition and agrees with those found by *Lolas et al.* (22). However, by nitrogen nutrition in the field the concentration of phytate-P in the seeds reaches a lower value than that following nitrogen nutrition in the pots. The choice of variety might be of more interest than that of the nitrogen nutrition.

According to the present results Vega tends to be a low phytate variety and Aramir, Claudia, Mona and Varunda have the highest phytate content and the concentrations in Diva and Salka are rather much influenced by nitrogen nutrition.

In the pot experiment (Table 3) the concentration of potassium is comparatively low in KVL 468 and Prisca and is little influenced by nitrogen nutrition. Alf and Proctor have a fairly low concentration at N_0 but it increases considerably with increasing nitrogen application. For potassium concentration in relation to nitrogen nutrition as a whole there is a decrease from N_0 to N_1 first and

then an increase to N_3. The explanation could be, that the decrease, which is related to high increase in yield, is a result of a dilution effect and thereafter potassium is transported up in the plant at the heavy nitrogen application N_2, N_3. The exceptions may to some degree be a result of the productivity variation among the varieties, for instance Alf gave a very small yield corresponding to N_3 and the concentration of potassium increased up to 7.6 g of K per kg.

The concentration of magnesium does not differ much from one variety to another but increases a little with increasing nitrogen supply as does the concentration of calcium. For calcium the concentration in Aramir, Proctor and Varunda is fairly low, whereas that in Alf, Lami, and Tron is markedly higher.

For the field experiments (Table 4) the decrease in concentration of potassium and phosphorus in relation to nitrogen nutrition may be a dilution effect. The concentration of calcium increases with increasing nitrogen application which is in agreement with Larsens (21) results. The concentration of calcium tends to be higher in Tron and Vega compared to Canova and Mona.

Conclusion

The content of nitrogen varies among the varieties and from site to site and the effect of nitrogen nutrition also varies. The viscosity of extracts related to β-glucan varied considerably among the varieties and as a result of nitrogen nutrition. To a certain extent the variation for the concentration of tannins, phytate, potassium and calcium was dependent on variety and nitrogen concentration. Phytate phosphorus amounted to an almost constant part of total phosphorus.

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