THE UNIVERSITY OF MANITOBA

AN EVALUATION OF SEED YIELD, PROTEIN CONTENT AND OTHER AGRONOMIC CHARACTERS OF FABABEANS (*VICIA FABA* L.)

by

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A B S T R A C T

Fababeans are a new crop for Canada. A preliminary investigation in 1970 indicated the high potential of this protein crop and initiated the present study in 1971. Over a 2 year period, several varieties of fababeans were tested on 31 locations over 8 provinces for seed yield, protein content and other agronomic characters. It was found that the seed yield of fababeans was similar to the wheat check on most locations; the wheat check outyielded the fababeans under extreme dry conditions. The average highest yield of fababeans (max. yield at each location) was 40.6 qu/ha or 3614 lbs/acre. On a varietal basis, Erfordia, Strubes, Pavane, Ackerperle and Diane performed similarly, while Maris Bead showed overall lowest seed yields.

The average protein content was found to be 29 and 17 percent for fababeans and wheat respectively. Thus on a protein yield basis, fababeans did outyield the wheat check by 70 percent. Fababeans were found to have two and a half times the lysine content of wheat but only half of its methionine content.

Other agronomic characters were found to be satisfactory; yield losses due to shattering of seeds may however become a problem.

A survey on 35 accession lines indicated that varieties originating from Europe seem to be superior to those of exotic origin. The survey also indicated favorable genetic variability with respect to

maturity, shattering-resistance and seed size, which might be of value in a breeding program.

In spacing and seed rate experiments, highest seed yields were obtained at close spacings of 15 cm and seed rates of 160 to 180 kg/ha.

The crop was attacked frequently by thrips in 1971 and at some locations by Caragana blister beetles in 1972. Minor damage occurred. Outbreak of Ascochyta fabae, a disease considered to be of great potential, was confined to two exotic lines at Winnipeg and occurred sporadically in the East.

"Vicia fabae, or horsebean, cultivar from the old world for the edible beans (which are not much fancied in this country, where we have better)".

A. GRAY, in LESSONS IN BOTANY, 1857.

I N T R O D U C T I O N

Western Canadian agriculture is continually searching for new crops in order to further diversify production. Prairie producers are frequently faced with major cereal surpluses and are forced to rely on production calamities elsewhere to create atypical markets.

In contrast to cereal surpluses Canada has never, in recent years, supplied the domestic demand for vegetable proteins. The short growing season in Western Canada prevents economic production of soybeans. Rapeseed protein has been plaqued with toxicity factors, the vagaries of the vegetable oil markets and more recently insect and disease problems. Field peas, the only other protein supplier of considerable acreage are low yielding and somewhat difficult to handle.

Fababeans (Vicia faba L.) are erect growing legumes which may have potential in this area. They are similar to wheat in maturity, high yielding and readily handled with conventional cereal equipment. Fababeans may be a valuable cash crop which would fit well into cereal rotations. It requires little or no nitrogen application and in fact

may have beneficial effect on subsequent crops. In mixed farming areas they could substitute for other more expensive protein supplements in the feed rations of all classes of livestock.

Fababeans are grown in all European countries, in the Mediterranean areas, North Africa and Asia. In Europe they are used mainly for livestock, while in other parts of the world they are also used for human consumption. The market volume of fababeans is not very substantial, but Britain does export to other European countries.

Fababeans have been grown in the Maritimes to a limited extend; they are also familiar to some Prairie farmers of European origin, but have never become established here. A preliminary study in this Department in 1970 indicated the potential of this crop and promoted further investigation.

The present study evaluates fababeans under Prairie conditions in terms of their adaptation, yield potential and quality. Studies were conducted to determine the optimum rates of seeding, row spacing, swathing date and inoculation procedure. Varieties collected from around the world were observed and evaluated for their use in a breeding program.

The study also involved a more comprehensive literature review than usual in order to compile information that may be of value at the introductory stage of a new crop.

1. REVIEW OF LITERATURE

1.1 Origin and distribution

O r i g i n. The centers of origin of Vicia faba were the Middle East and North Africa. It is assumed that the species Vicia faba is phylogenetically younger and more advanced than the species V. cracca, as exemplified by a shift towards autogamy, decrease in the total chromosome length and changes in habitat pattern. This evolutionary process may have happened in the younger Tertiary, when due to the decline of the Tethys, large territories in the Mediterranean and Oriental region became newly colonized, (Hanelt & Mettin,1970).

It is believed, that fababeans were selected in the early history of agriculture, because of their erect stems and easily threshed pods. Today, no wild forms of Vicia faba are known, (Bond, 1969; Hanelt and Mettin, 1970).

D i s t r i b u t i o n. This vigorous annual was known to ancient Greeks and Egyptians and has been under domestication for many millenia. Historically, it was the only widely used edible bean in the Old World before Phaseolus was introduced from America,(Janick et al, 1969). In an old English document dating back to the 11th century, it states that one of the duties of a revee was to sow beans in spring (Anonymous, 1969). A diversity in hardiness and day-length requirements allowed the species to spread to northern Europe, but it is grown very little in North America. According to Muratova (1937),

cultivated species of V. faba were first introduced to the New World by Captain Hosnold in 1602, who successfully planted the crop on Elizabeth Island, off the coast of Massachusetts.

T a x o n o m y. Vicia faba L. belongs to the Leguminosae family and is one of many species in the genus. Most of the species are annual vetches some of which are utilized as forage. The closest relatives of V. faba are considered to be V. narbonensis, V. serratifolia and V. pliniana. The relationship is not that close however, as V. faba has a 2n number of 12 chromosomes, while V. narbonensis, V. serratifolia and V. pliniana have a chromosome complement of 2n = 14. The common vetch V. sativa has 12 chromosomes. None of the above species will cross with V. faba (Bond, 1969). Janick et al (1969) state that interspecific spontaneous outcrossings do occur with a number of wild vetches; and Bond (1970, l.c.) cites reports of interspecific crosses involving Vicia faba, conducted in the Soviet Union. The whole group is considered as a descending aneuploid series, from 2n = 14 to 2n = 12 to 2n = 10. The most conspicuous variability occurs at the 2n = 12 level, (Hanelt and Mettin, 1966). Hermann (1960) lists 35 species of Vicia occuring in North America; some are cultivated and others like V. narbonensis and V. serratifolia are established locally as weeds. V. cracca, a perennial, the bird vetch or tufted vetch, which may be one of the ancestors of V. faba, is widely distributed, from Newfoundland to British Columbia growing in fields, thickets and along roadsides.

The classical division of the species V. faba is into the three subspecies V. faba major, V. faba equina and V. faba minor

based mainly on seed and pod characteristics. Recently, Picard (1963) crossed the 3 subspecies and used the specific behavior of certain crosses to explain these divisions. All three species are used for human and animal consumption. Traditionally, the big-seeded ssp. major is used in Europe for human consumption, while in parts of Africa and Asia the small seeded species are also used, (Bond, 1969).

T h e b r o a d b e a n, Vicia faba major Herz. (Syn. Garden-bean, Longpod, Windsor bean) is characterized by a long pod of 15 - 20 cm containing 3 - 4 seeds. The seeds are kidney-shaped, flat and have a thousand seed weight of 900 - 1200 g. The seed colour is predominantly white or green, but black seeds do occur. This ssp. has found wide distribution and is the only one of the subspecies commonly grown as a garden vegetable. Broad beans have a shorter growing season than the smaller seeded relatives. Their stem is weak and tends to lodge, (Sjödin and Ellerström, 1968; Bond, 1969).

T h e h o r s e b e a n, Vicia faba equina Pers. (Syn.Field bean, fababean, Silkworm bean in China) is clearly distinct from the broad bean. The thousand kernel weight ranges between 500 and 800 g, (Sjödin and Ellerström, 1968). The seeds are slightly kidney-shaped and flat. They are usually of tan colour but some black seeded varieties exist. The pods are 6 - 8 cm long and average 3 seeds. Pods are set in clusters of 2 - 3 and located on the nodes of the stem.

T h e t i c k b e a n, Vicia faba minor Beck. (Syn.field bean, fababean), comprises all the small-seeded varieties with a thousand kernel weight ranging from 200 - 500 g. The seeds are almost spherical. Most varieties presently grown belong into this group, (Sjödin and Ellerström, 1968; Bond, 1969).

1.2 Growth Requirements

S o i l s. Fababeans are regarded as a crop for heavier soils, due largely to their use as a break crop for cereals on these soils. Actually, they can be grown on a range of soils but with some limitations (North, 1969; Ellis, 1969; Anonymous, 1970a): Poor drainage and waterlogging are detrimental but fababeans do better under these conditions than most crops. Very light soils in drought areas and soils with a pH below 6.5 should be avoided. Jones (1963) indicates that drought in the early stage of growth is a greater hazard than waterlogging. Sebilotte (1963) found horsebeans very sensitive to a hard pan in the soil and concluded that plants with a large tape root are especially vulnerable to soil compaction. A well worked and fairly loose seedbed with a minimum of consolidation should provide the best conditions for optimum growth. Fababeans do develop a large tape root and are not considered as being very strong rooted (Anonymous, 1970a).

F e r t i l i z e r. Being legumes fababeans fix elemental nitrogen (N) through their association with Rhizobium bacteria and therefore are not dependent on applied N. It is however advisable, especially on poor soils and early plantings to apply a starter dosage of N, ranging from 15 - 50 kg/ha N, (Ellis, 1969; Anonymous, 1970b). The variability of seed yields has led many workers to the conclusion that N-fixation of the Rhizobiums may be limited and yield increases could be obtained by applying higher rates of N.

McEwen (1970a) applied up to 336 kg/ha of N (3 cwt/acre) broadcast in the seedbed along with sufficient phosphate and potassium.

At all rates (112, 224 and 336 kg/ha) germination was affected and seedling stand decreased. At the highest level, a seed yield response of 347 kg/ha was obtained. McEwen concluded based on the minor yield response that seed yield was not limited by the N-fixing capacity of the bacteria. Other workers (Anonymous, 1970a; Sjödin et al., 1972) also believed that Rhizobias reach a ceiling in their ability to fix N and that the plant could utilize more. Again, responses to N over several years were negligible on both seed yield and protein yield. A split application was then applied (Ellis, 1969; McEwen, 1970b) in order to provide a steady source of N over the growth period. Seed yield was increased significantly by an increased number of tillers and pods, (McEwen,1970b). This approach prevented the loss of seedlings but at the same time lengthened the growing period and the amount of lodging increased.

As to the other nutrients, a basic dressing of phosphorus and potassium is recommended, (Ellis, 1969; Anonymous, 1970b). There are indications that potassium is sometimes limiting (Houg, 1960; Anonymous, 1970a) and should be given more attention. Also, placement of potassium is more effective than broadcasting. As already mentioned, beans should not be grown on soils with pH below 6.5. Moffatt (1967) could demonstrate increasing seed yields by application of lime up to pH 7.

There are also indications that response to microelements can be obtained. On alluvial soil, Nikolov and Peterburgskii (1967) obtained response to applied molybdenum and magnesium.

1.3 Seeding Operation

Date and Depths of Seeding. Several reports indicate that fababeans should be planted as early as possible, before cereal planting begins. Yields decrease significantly with delayed plantings and the risk of pest and disease losses is higher and harvesting will be delayed, (Derenne, 1965; Robinson, 1968; North,1969; Anonymous, 1970b). At early plantings in cold and damp soil, a seed dressing with thiram or captan is advisable, despite the very sturdy seedlings, (Anonymous, 1970b). Although no specific data are available as to the frost tolerance of fababeans in the seedling stage, it is generally believed that they can withstand temperatures below 0° C. Robinson (1968) reports injuries on fababeans at -3.3^{o} C (26° F), but the damage was less severe than that on barley. He also gives data of a trial planted May 3 at Rosemount/Minnesota, which yielded 1646 kg/ha as compared to a planting on May 23 with a seed yield of 658 kg/ha. Similar results were obtained in Nova Scotia (Hough, 1972) on field scale trials; two plantings in June resulted in a complete loss.

As to depth of planting, there is evidence that fababeans are in most cases planted too shallow rather than too deep. North (1969) mentions that at planting depth of 30 cm (12 in) seed yield was only reduced by 10 percent. Shallow plantings followed by dry periods can be held responsible for poor stands in many cases. A depth of 7 - 8 cm seems to be most favorable for adequate emergence, (Robinson, 1968; North, 1969; Anonymous 1970b). In a trial with several depths of planting, Kushnir (1969) obtained highest seed yields at 8 cm, as compared to 4 to 6 and 10 to 12 cm. The hard, dry seeds of fababeans take

longer to absorb water and germinate than does seed of common beans. The time from planting to emerging varies from 8 to 22 days.

It has been common practice in the U.K. to broadcast beans and plow them under, (Anonymous, 1970b). This reduces planting operations and compaction. Moreover, it allows discing, harrowing and herbicide application to the planted crop with little risk. Robinson's (1968) results indicate that this could also be feasible under North American conditions, but that it delayed ripening.

S e e d R a t e a n d S p a c i n g. Several workers (Hodgson and Blackman, 1956; Picard and Sigwalt, 1960; Bardossy, 1968; Robinson, 1968; Kushnir, 1969; Simon, 1970a and 1970b; Anonymous, 1970a and 1970b and Sjödin et al., 1972) have reported data on seed rate and spacing experiments, but most of them are not very conclusive, (North, 1969). The fababean plant is highly adaptable and shows a plastic response to various plant densities. Hodgson and Blackman (1956) noted the highest seed yield at the highest level of density, namely 67 plants/m^2. Similar results are reported by Picard and Sigwalt (1960), with optimum densities ranging between 60 - 90 plants/m^2. The same authors also could not detect any variety x population interaction nor population x spacing interactions in their material.

In general, increasing seed rate means a decrease in branching and the number of pods per plant. But it was found that seed weight and seeds per pod showed little response to various densities. Hodgson and Blackman (1956) concluded that seed production is solely governed by the number of mature pods formed per unit area.

The recommended seed rate in Britain varies from 194 - 242 kg/ha

(160 - 200 lbs/acre), with row spacings of 18 - 35 cm (7 - 18 in), (Anonymous, 1970 a and 1970 b). There is evidence that the closer spacing gives higher yields, (Simon, 1970a and 1970b; Sjödin et al., 1972). On a 3 years average, Sjödin et al. report approximately 10 percent seed yield increase at row spacings of 14 cm as compared to 45 cm. There was also evidence that seed yield increased with seed rate of up to 240 kg/ha, with the response leveling off around 180 kg/ha.

Under the more dry conditions of the small Hungarian Plain, Bardossy (1968) tested spacings of 20, 60 and 45 + 15 cm twinrows. In drier seasons spacing had little effect on seed yield. In a wet season the twinrows with 560 000 plants/ha (approx. 240 kg/ha) out-yielded other treatments.

1.4 Inoculation

Fababeans, as a legume, live in symbiosis with the bacteria Rhizobium leguminosarum. This symbiotic relationship supplies the crop with organic nitrogen thus making it independent of artificial nitrogen supplementation.

The rhizobias effective on fababeans are also responsible for nodulation on peas and vetches. Moffatt (1967) found no differences due to inoculation on soil which had grown beans previously. Similar results were obtained by Caldwell and Vest (1970) and Ham et al. (1971) on soy-beans. In soils containing rhizobias, only 5 - 10 percent of the nodu-les formed could be traced back to the applied inoculum, (Caldwell and Vest, 1970).

The magnitude of nitrogen fixation by a rhizobia strain can be measured by protein content of the crop and by the seed yield, (Erdman, 1953). As a field guide, fixation may be judged by the number of nodules formed as well as by examining the nodules. Once exposed to the air, a cut surface showing reddish discolouration indicates efficient fixation. An example of a quick test is also given by Brockwell (1956) working with subterraneum clover. This crop showed red-pigmented leaves when nitrogen was deficient, i.e. nodulation not effective. The anthocianin disappeared in the presence of effective nitrogen fixers. On the assumption that the yield potential of fabebeans is limited by the capacity of the nitrogen fixing bacteria, McEwen applied high doses of nitrogen to fababean crops. The response to 336 kg of applied nitrogen was however insignificant, indicating that the Rhizobia could supply all the nitrogen the plant needed. McEwen (1970a) calculates that with an average crop the removal of N is of the magnitude of 145 - 213 kg/ha, (130 - 190 lbs/acre), plus that left behind in crop residue.

In pot trials, conducted with sterilized soils, Lapinskas (1968) obtained yield increases with inoculation from 35 - 45 percent. Response was more pronounced in the presence of P, K and Ca application.

While large applications of fertilizer had no effect on seed yield, nodule formation was affected. In the experiments by McEwen (1970a), nodulation was reduced by 50 percent on plots receiving high treatments of nitrogen. In a study by Schmidt (1955), early application of $Ca(NO_3)_2$ had a favorable effect on nodule formation. This supports the common practice of a starter application of nitrogen, (Anonymous, 1970b). Experiments by Korovin and Vorobev (1967) under

controlled conditions showed that cool temperatures had little effect on nitrogen fixation. They concluded that N can be fixed and is available to the plant at all temperatures suitable for plant growth.

Besides the direct effect of nitrogen fixation, crop residues are of considerable value to the following crop. This is partly due to the nitrogen and partly attributable to the good physical conditions of the soil following fababean production. McEwen (1970a) reports good response of wheat planted after fababeans. This residual effect was also noted by Robinson (1968), who reports higher yields of corn following either fababeans or vetches than following oats.

I n o c u l a t i o n P r o c e d u r e. The inoculum is commonly applied in powder form mixed with the seed prior to planting. There is evidence that other methods of application might be more condusive to optimum nodulation. Date (1968) found that only lime-pelleted rhizobias had a good rate of survival under dry conditions, since pelleted rhizobias are less subject to dessication. Furthermore, toxic factors in the seed coat affecting the rhizobias (Thomson, 1960) will be of less hazard to pelleted inoculum.

So far little information regarding strain specifity is available. Lapinskas (1968) tested 35 local Rumanian strains adapted to Vicia faba. Of these, 5 were more effective than the standard line. Working with soybeans, Caldwell and Vest (1970) found noticeable variability in the nitrogen fixation of 28 isolated strains. They found a marked strain x year and strain x variety interaction. They concluded that specific strains would be superior to commercial products, which are mixtures and suitable for several crops. Erdman (1953) lists the crops which

are in the same group as fababeans and normally treated with the same inoculum. This group comprises the field and garden peas, all Vicia ssp. as well as Lathyrus ssp. and lentils, (Lens culinaris).

1.5 Weed Control

C u l t i v a t i o n. Traditional weed control in fababeans was by means of harrowing prior to or shortly after emergence, inter-row cultivation and howing. The effectiveness of harrowing depends on weather and soil conditions as well as growth stage of the weeds and can be exercized over a short period of time only. Inter-row cultivation and howing is more effective. To facilitate this rows have to be planted at least 30 cm apart. As Griffiths (1969) points out, these methods were neither condusive to optimum yield nor was it possible to remove weeds satisfactorily in a wet season. Today, European farmers plant as close as 12 cm and depend on chemical weed control.

H e r b i c i d e s. As Griffiths (1969) states, there has been a dramatic increase in the acreage of fababeans over the past few years which can partly be attributed to improved methods of chemical weed control. Griffiths also remarks that through the use of Simazine the fababean crop is now one of the cleanest in the rotation. Most of the information available on chemical weed control is of European origin and due to climatic differences is of limited value in North America.

Simazine is by far the most widely used and successful herbicide in Western Europe, as indicated by numerous workers (Bullen and Hughes, 1960; Elliot, 1960; Moffatt and Hill, 1960 and 1961; Griffiths, 1969; Anonymous, 1970a; Javorska, 1970; Simon, 1970a; Bond, 1972). Simazine can be applied pre or post emergence, but the seeds need depth protection and should be sown at least 7.5 cm (3 in) deep after soil consolidation. Uptake of Simazine is entirely through the roots so beans not planted deep enough will pick up the chemical and produce a characteristic black marginal scorch. If sufficient is absorbed the plant will become stunted and may die eventually. Application is advised prior or as soon after planting as possible before weeds become established.

In a series of trials over a 4 years period, Simons (1970a) reports slight yield increases due to application of Simazine as compared to inter-row cultivation. Simazine was equal to a combination of cultivation and hand howing. Good control of weeds has been achieved with as little as 0.56 kg/ha (0.5 lbs/acre) (Bullen and Hughes, 1960; Elliot, 1960; Moffatt and Hill 1960 and 1961). The recommended rate in Britain is 1.68 kg/ha of 50 percent a.i. (1.5 lbs/acre), (Griffiths, 1969; Bond, 1970). At this rate, good control of annual grasses and broad leaf weeds is achieved, but Simazine has little effect on Agrostis ssp., Agropyron repens, Avena ssp., Galium aparine and on many deep rooted broad leaf weeds such as thistle, (Anonymous, 1970b) The effect on wild oats is variable, depending on the depth from which they germinate, (Griffiths, 1969).

At rates of 2.24 kg/ha (2 lbs/acre) efficiency of weed control increased but was not reflected in seed yields (Bullen and Hughes, 1960 and Elliot, 1960). Yield depressions were reported by Moffatt and Hill (1961) with applications of 0.56 and 1.12 kg/ha. Bullen and Hughes studied the residual effect on the following wheat crop, but could not find anything attributable to Simazine. Dry weather was partly held responsible for the failure of sufficient weed control by Moffatt and Hill (1960 and 1961). The long persistence of Simazine gives continuous weed control, but also causes a delay in planting of the crop to follow since 6 - 7 months should elapse before new crops can be planted, (Griffiths, 1969; Anonymous, 1970a).

In North American experiments with Simazine,Robinson (1968) found Simazine at 1.12 kg/ha was equal to the control but higher rates depressed seed yields. Hough (1972) reports on field scale trials conducted in Nova Scotia, where rates of 0.8 - 1.12 kg/ha gave good weed control.

Dinoseb is the only herbicide used to any extent in post emergence weed control. It is used on light and organic soils where Simazine is not recommended. Dinoseb kills weeds by contact and for optimum results the weeds should be sprayed in the seedling stage. The crop may become scorched but normally recovers quickly, (Griffiths, 1969). Reports by Krejciv (1965), Javorska (1970), Anonymous (1970a) and Hough (1972) indicate that good results can be obtained if the crop is sprayed at a rate of 4 - 5 kg/ha when the plant height is between 5 and 15 cm. However, yield reductions have been observed (Anonymous, 1960; Javorska, 1970).

On field scale trials in Nova Scotia, Hough (1972) using 4.48 kg/ha (4 lbs/acre) achieved good weed control on 2 locations, while a third location showed no response, indicating that timing of application is critical. For this and other reasons (unpleasent handling) Bond (1972) states that most farmers in England now use Simazine.

Besides Simazine and Dinoseb, several other compounds have been used for weed control in fababeans. The information available is limited and inconclusive. References to these studies are listed below.

Compound	Time & Dosage kg/ha	Effectiveness	Reference
50% Prometryne	pre em., 2-3	better than Dinoseb	Krejciv,1965
" "	3.5	various results	Robinson,1968
Maloran (N-(4 brom-3-chlorfeyl)-N-metoxy)	pre em.3 & 4	good	Javorska,1970
Barban (Carbyn)	post em.	against wild oats	Anonymous,1970a
Monolinuron	pre em.,1.2-1.5	-	Schmidt, 1971
Linuron (Lasso)	pre em., 2.0	-	Schmidt, 1971
"	-	excellent	Hough, 1972
Methabenzthiazuron (Tribunil)	pre em., 3-4	-	Schmidt, 1971
Patoran & Lasso	-	crop injuries	Hough, 1972
EPTC (Eptam)	pre em., 3.5	crop injuries	Robinson, 1968
Chlorpropham + fenuron	1.1 + 0.3	-	Anonymous,1970b
Triallate	pre em.,1.6 a.i.	against wild oats	Anonymous,1970b

1.6 Flowering and Pollination

F l o w e r i n g. The flowers are in clusters of 6 to 8 located at the nodes of the stem. Data obtained as to the number of flowers forming mature pods vary. Rowlands (1955) found that 25 percent of the flowers set seed, while Kambal (1969a)found that in the arid subtropical climate of Egypt only 10 percent were setting seed. In his experiment abscission of open flowers and young pods took place. Abscission of flowers may also be caused by low night temperatures, (Bond 1972). Rowlands (1955) found on the average only 3 seeds per pod, indicating that only 50 percent of the ovules formed seeds. Kambal (1969a)indicates that the distal embryos are developed first, produce more Auxin and have a competitive advantage, while seeds at the proximal end are aborted more frequently. Data of Gabelmann and Williams support this theory (Kambal, 1969a l.c.). The abundancy of flowers and ovules produced together with the indeterminate flowering habit ensures an elastic response to weather conditions, pollinators and growing conditions, (Bond, 1969).

P o l l i n a t i o n. Many studies have been conducted to elucidate the pollination requirements of fababeans. In view of the variable yields obtained it was hoped that a better understanding of this aspect might help in stabilizing production. Fababeans are insect pollinated, but in the absence of insects the beans still set seed. Consequently, fababeans are frequently regarded as self-pollinating, (Anonymous, 1970a), while others (Derenne, 1964; Hanna and Lawes, 1967; Bond, 1969; Kambal, 1969a) found 30 - 60 percent outcrossing. Interestingly, the German Seeds Act lists no requirement for distance isolation

between seed increases of different varieties, thus inferring a selfpollinating habit.

This dualism of pollination is believed to maintain the species in the absence of pollinators and at the same time provide vigorous growth through heterozygosity, (Drayner, 1956). Drayner states also that "the overall effect will be to maintain the population in a stable state of intermediate heterozygosity".

P o l l i n a t o r s. As Bond (1969) notes, the long tongued bumble bees (Bombus hortorum and B. agrorum) fertilize most of the crop in the U.K. by reaching the nectar through the long corolla. Bombus terrestris which have short tongues are considered as being robbers: they pierce the base of the corolla to collect nectar, but do not effect fertilization, (Bond, 1969). Honeybees when present make 3 types of visits on fababeans. Firstly, they can collect nectar through the holes made by bumble bees; secondly, obtain extra floral nectar and thirdly, enter the flower for nectar and pollen. Obviously, only visits of the second and third type allow for fertilization, (Free, 1962).

The role of pollinators in fababeans and their ultimate effect on seed yield is controversial. The data available range from increases of 100 percent (Scriven, 1961; North, 1969) to a negligible effect (Free, 1965; Martyanova, 1967). Varietal differences may partly be held responsible for these contradictions. Free (1966) found in his experiments, that seed yield in broad beans increased in the presence of bees, while horsebeans showed no response. All experiments evaluating the effect of insect pollinators necessarily have to be

done in cages, which may bias the results (Free 1966).

While the role of insect pollinators is debated, they do have a positive effect in hastening maturity. It was found that in the presence of insect pollinators more pods are set on the lower nodes of the stem, leading to earlier and evener maturity (Riedel and Wort, 1960; Robinson, 1968; Anonymous 1970b). In the absence of pollinators, pods are distributed more evenly over the entire length of the stem.

1.7 Insects and Diseases

Fababeans are attacked by a number of insects and diseases, some being quite destructive.

B l a c k A p h i d (Aphis fabae Scop.). This is the most serious pest in Europe. The damage in the Southern U.K. is such that a forecasting system is proposed to indicate the likelihood of attacks (Anonymous, 1970b). Small, early infestations during flowering might increase seed yields, according to Banks and Macaulay (1967), with the aphids being a pollinating agent. With heavy infestation losses can become large. Gould and Graham (1969) report a peak population of 3000 aphids/plant and a consequent reduction in seed yield of 750 kg/ha. These results are supported by the findings of Way (1955), who obtained yield increases ranging from 500 kg/ha to 2250 kg/ha by controlling aphids. A field scale trial in Nova Scotia was completely destroyed by aphid attack (Hough, 1972).

Effective insecticides include disulfton, phorate (both granular),

demeton-S-methyl, (Metasystox, a systemic) meanzone and vamidothion, (Gould and Graham, 1969; Way, 1955; Way and Heathcote, 1966). Granular forms have immediate effect as well as a 2 - 3 weeks persistence. Disulfton is also taken up by plant roots and becomes systemic (Griffiths, 1969). Endosulfan preparations (Thiodan, Beosit) are especially recommended at flowering time because of their low toxicity to bees,(Schmidt, 1971).

Early planting and wider row spacing reduces aphid infestation. Way and Heathcote (1966) found that the number of plants per unit area was inversely related to the number of plants infested. Experiments of Vullioud (1969) showed that beans grown in mixtures with oats were less infested than beans grown alone. There are also indications of varietal differences. In a study by Tambs-Lyche and Kennedy (1958) the low yielding variety Rastatter had the least infestation.

Other aphids infesting fababeans are: Acyrthosiphon pisum, Mycus persica and Megoura viciae, (Heathcote and Gibbs, 1962). Besides the direct damage caused by sucking they are also vectors in transmitting virus diseases.

The pea and bean weevil (Sitonia ssp.), which cause the familiar notches around leaf edges, attacks fababeans but cause little damage, (Griffiths, 1969). The bean seed beetle (Callusobruchus chinensis) cuts through the seed coat to lay its eggs. The larvae then feeds on the seed and destroys it, but damage again is marginal. A thick seed coat has been reported as giving resistence, (Bond, 1969). Another pest is the stem eelworm, Ditylenchus dipsaci, a seed and soil born pathogen which causes stunted growth and shrivelled seed, resulting in yield depressions, (Hooper, 1971).

C h o c o l a t e s p o t (Botrytis fabae and B. cinera). This disease is most serious in winter beans, (Griffiths, 1969). Since the causal agent is present in North America it may become important. The disease has been identified in Nova Scotia, (Hough, 1972). The symptoms are clearly defined, reddish-brown circular spots on the leaves, stems and pods. The spots are not restricted in size but can merge and cause blackening, partial defoliation and death of the plant. Infested seeds show brown markings. Rapid spread of the disease is encouraged by humid weather and thick stands, (Anonymous, 1970b).

The disease is carried over on debris, volunteer beans and occasionally on the seeds (Griffiths, 1969). Control measures are deep plowing of crop residues, long term rotations and the use of clean seed. Bond (1969) reports that Mediterranean varieties carry resistance to the pathogen but that they have not yet been utilized in European breeding programs.

L e a f a n d p o d s p o t, (Ascochyta fabae Speg.). This disease can be very destructive. The symptoms are easily confused with chocolate spot, but differ in having small brown fruiting bodies (pycnidia) arranged concentrically in the center of the lesions, (Griffiths, 1969). The lesions are irregular, about 1.5 cm in diameter, slightly sunken with grey centres and brown margins. Red-brown lesions on the stem, which may elongate, are also quite common. Pods and seeds can also be affected. Infected seeds are characterized by the presence of round, dark brown to black lesions and may have "target spots" in severe cases,(Beaumont, 1950; Hewett, 1966; Anonymous, 1970b).

Cool moist weather is most favorable for the spread of the disease. As with chocolate spot, A. fabae has already been reported and identified in Nova Scotia, (Hough, 1972). Beaumont (1950) has shown that A. pisi also attacks fababeans. Ascochyta pisi is destructive on peas in Canada, (Gfeller, 1961).

Spread of the disease is mainly through infected seed. Once established in the crop, spores are dispersed by rain and wind causing further infestation. The only satisfactory method of control is clean seed. Deep plowing of crop residue and wide placings in the rotation helps to check the pathogen. Mercury seed treatment was found ineffective, (Hewett, 1966; Derenne, 1967; Griffiths, 1969). Resistance to A. fabae has been found in Russian varieties but has not been used in breeding, (Bond, 1969). As Hewett (1966) notes, a dry spring completely controls the disease. In severe cases and on valuable crops (like broad beans), fungicides such as Maneb or Zineb can be used, (Schmidt, 1971).

S t e m r o t, (Sclerotinia trifoliorum). This disease blackens the stem base and causes wilting. It is associated with close cropping and/or cropping of red clover. Mycelium and sclerotia may be found in the pith of the stem, (Griffiths, 1969). Control is by rotational procedures and crop hygiene. No resistance is known, (Bond, 1969; Anonymous, 1970b).

F o o t r o t, (Fusarium avenaceum). Foot rot is only found when beans were planted in cold, wet soil. The cult. Kleine Thüringer has been reported to show resistance, (Bond, 1969).

Bean rust, (Uromyces fabae). Bond (1969) reports that rust usually develops too late in the season to be of importance. Resistance has been found in Rumanian varieties.

Bean Leaf Roll Virus (BLRV) (syn. with pea leaf roll virus, Aldrich, 1965). Amongst the virus diseases found on fababeans, BLRV is the most destructive (Heathcote and Gibbs 1962). All viruses on fababeans attack peas and have been reported in Canada, (Gfeller, 1961). The aphids are known to be vectors in transmitting this virus, but A. pisum Harris is the most important, (Heathcote and Gibbs, 1962). Varietal differences in susceptibility have been found with earlier maturing varieties being more susceptible in general, (Aldrich, 1965). The cultivars Herz Freya and Ackerperle are susceptible, while Strubes shows resistance, (Bond, 1969). The symptoms as described by Heathcote and Gibbs (1962) and Aldrich (1965) are leaf rolling; leaves are stiff and cupped with interveinal chlorosis and are heavily marbled. Also, a yellowing and thickening of the leaves is noticed, and eventually they become brittle, (Anonymous, 1970b).

Pea enation mosaic. This virus causes discrete, translucent chlorotic lesions but has been of little importance, (Heathcote and Gibbs, 1962).

Pea mosaic causes a marbling of the leaves similar to pea enation mosaic. Besides being vector transmitted it can occasionally be transmitted through the seed, (Heathcote and Gibbs, 1962).

Bean leaf yellow mosaic virus. This virus has been reported in beans but is apparently of no importance, (Gaaker, 1963).

1.8 Harvesting

In general, fababeans are not difficult to harvest. The crop has stiff straw and lodging is rare; pods are set high and shattering is minimal in the new varieties, (Anonymous, 1970b). While plants are relatively tolerant to low temperatures in the spring, early frost before the seeds are mature can do considerable damage, (Sjödin et al., 1972). In their experiments frost 2 weeks before harvest reduced germination.

D e s i c c a n t s. The indeterminate growth habit can be troublesome, and may be aggravated by late planting and wet conditions, resulting in delayed and uneven ripening. Under these circumstances desiccants have been used successfully. It must be noted however that at the time of application most of the pods should be ripe in order to avoid losses in yield and quality, (Willows, 1969; Anonymous, 1970b). Applications of desiccants can create problems in dense stands, for the spray boom has to be above the crop to be effective; wheel damage can be considerable, (North, 1969). In general, good results have been reported with diquat at a rate of 3 l/ha, (Gaaker, 1963; North, 1969; Anonymous, 1970b).

S w a t h i n g. No European literature is available on this aspect. Robinson (1968), working in Minnesota, indicates that swathing is possible and often necessary because of weed infestation.

S t r a i g h t c o m b i n i n g. This is the normal procedure used in Europe. The majority of the pods should be black and the seeds

hard. At this stage all the leaves have dropped but the stems and petioles are still green, (Robinson, 1968). Harvesting has to be done before shattering becomes serious, although the new varieties have been improved in this respect, (Willows, 1969).

The ripe crop threshes easily but to avoid seed damage the concave should be opened and cylinder speed reduced, (Anonymous, 1970b). Hough (1972) reports no serious harvest problems in Nova Scotia in 1971; the moisture content of this crop ranged from 15 - 19 percent.

D r y i n g. Moisture contents of 16 percent and above cause most problems in the process of milling, handling and feeding fababeans. Since this crop is the latest to be harvested in Europe, under increasingly moist conditions, these problems are common. The big seed surrounded by a thick coat makes airflow and drying slow and difficult. Too rapid drying at high temperatures results in cracking of the seed. Uneven drying with the outside of the seed dry and the inside still wet can also cause quality problems. At a moisture content of 18 percent the beans cannot be ground as the flour becomes a sticky paste. A moisture content of 14 - 15 percent is suggested for bulk storage over a period of several months (Willows, 1969; Anonymous, 1970b).

1.9 Composition and Feeding Value

The high nutritional value of fababeans has long been recognized and the USDA farmers bulletin of 1918 states that they are usable in rations of horses, cattles, swine and sheep,(Brisson *et al.*, 1950 *l.c.*).

In Europe, beans are used in the diets of all classes of farm livestock. They are fed whole, cracked or ground according to the need of the animal, (Eden, 1969). As Eden also notes, reservations have been expressed from time to time that fababeans may not be as valuable a food as is claimed. It is said that fababeans fed to pigs can cause "Thickbloodedness" and other hard to describe negative symptoms, (Hofmann, 1968). Most of the problems arise when beans are stored damp causing rancidity and mouldyness. If fed they cause reduced food intake and other disturbances, (Hofmann, 1968). Problems have also arisen when feeding newly harvested beans. As with cereals and corn, fababeans should be subjected to a maturation period of 6 - 8 weeks after harvest. It is not known what changes occur during this time.

A n t i - t r y p s i n f a c t o r s. There is evidence in older literature (Schonie and Ambe, 1955) that fababeans contain trypsin and chymotrypsin growth inhibitors which cannot be destroyed by autoclaving. A recent paper by Nitsan (1971) confirms the results of Schonie and Ambe that these inhibitors were not destroyed by heat treatment, but the levels of both inhibitors were rather low, approx. 1/60 to 1/30 of that found in raw soybean meal. Wilson et al.,(1972) conducted studies in vitro and presented evidence of the occurrence of trypsin inhibitors in both the testa and cotyledons. Under the conditions of the assay soybeans had 5 times the inhibition activity of whole fababeans. Autoclaving at 110^{0} C for a period of 40 min. eliminated inhibition. The authors conclude that this chemical detection of trypsin inhibitor activity is not conclusive evidence of an adverse nutritional effect, other heat labile factors which were not assayed

could also be involved. Eden (1969) in an earlier review concludes that there is little evidence supporting their presence.

P r o t e i n. In a comprehensive survey conducted by Eden (1968), crude protein levels on a dry matter basis ranged from 25.5 - 35.4 percent. The true protein values showed a parallel trend and ranged from 22.3 to 31.7 percent of DM. Average figures for both are 31.4 and 28.2 percent. Other authors give similar values, (Robinson, 1968; Eden, 1969; Bond, 1970). The lower values obtained are found to be associated with bigger seed size, (Eden, 1969). Bond (1969) found that protein was negatively correlated with lysine content and infers that selection for higher yield may mean inferior protein quality.

A m i n o a c i d s. Protein quality is determined to a large extent by lysine content and Eden (1969) points out that in this respect beans rank second after soybeans in the excellence of lysine content. This is impaired somewhat by the low content of methionine. Nitsan (1971) gives lysine values for heated soybeans and raw horsebeans of 6.3 and 5.4 g/16 g N, respectively. The values for methionine are 1.5 and 0.7. Little difference seems to exist between other amino acid contents of soybeans and fababeans. Bond (1970) indicates that he observed differences in lysine content in his breeding material and suggests possibilities for selection. Eppendorfer (1971), by application of sulphur could increase the levels of methionine and cystine. In feeding trials, this material was superior to that with synthetic additions.

Eden (1968) gives an average value for crude fibre of 8 percent, nitrogen-free extracts (carbohydrates) of 55.2 percent and ether extract (fatty acids) of 1.5 percent. In the fatty acid composition it is noteworthy that they contain a high proportion of linoleic acid, which is important for egg size in poultry, (Clarke, 1970).

C a t t l e F e e d i n g. Fababeans are the oldest type of concentrated food used in cattle rations, and have proved to be a satisfactory source of energy and protein when substituted for oilseed meals, (Eden, 1969; Anonymous, 1970a). For calves, 15 percent fababeans in the rations is recommended as the sole vegetable protein supplement. Finishing beef cattle older than 9 months can be fed with a diet of cereals and beans in a ratio of 5:1. This again will provide all the protein necessary, (Eden, 1969).

Comparisons have also been made between beans preserved with propionic acid and dried beans: animal performance was unaffected, provided the ensiled beans were sound and no moulds had developed, (Anonymous, 1970a). MacLeod et al.,(1972) fed beans preserved with propionic acid and found daily live weight gains intermediate between fishmeal and soybean meal, but nitrogen digestibility was slightly below the controls. The same experimentors compared whole and rolled beans fed to steers and found DM intake higher when beans were in whole form, but nitrogen digestibility was lower.

Eden (1969) indicates that fababeans can provide the whole supplement of protein for milking cows. In Nova Scotia, milking Holsteins have been fed fababeans for 2 years with good results, (Hough, 1972). The following mixture is recommended to British

farmers (Eden, 1969), fed at a rate of 4 lbs per gallon of milk:

4 cwt rolled barley
3 cwt cracked beans
2 cwt dried sugar beet pulp
1 cwt ground nut cake
28 lb minerals/vitamins supplement.

H o g F e e d i n g. The digestibility of fababeans is higher than that of barley, (Bond, 1970). This and the high lysine content should make them a very suitable food for pigs, (Anonymous, 1970a; Clarke, 1970). In a recent experiment with weaners and fattening rations of baconers, fababeans were included up to 20 percent of the diet, replacing all the fishmeal. Inclusion of beans did not reduce palatibility, or adversely affected food conversions or live weight gains. The amount of protein fed was lower than normal in order to reveal any deficiency in the beans, (Anonymous, 1970a). In the same experiments groups were fed fababeans up to 30 percent of the rations without ill effects. Hofmann (1968) reports data where fababeans replaced soybeans with amounts increasing up to 750 g daily per head. In one trial, daily live weight gains were 706 g and 781 g for control and an all fababean-protein diet, respectively. Other trials were similar, with barley having slightly better food conversions. Danish results (Sjödin and Ellerström, 1968 l.c.) show the same tendency, but the need for the addition of methionine is stressed.

Clarke (1970) calculated least cost formulations and reports, the inclusion of fababeans at the rate of 4 to 10 percent in pig rations seems to be attractive because of their high lysine content.

A useful practical effect of including beans in the diets of pigs is that the carcass fat is usually very white and firm, an attractive point to the consumer, (Eden, 1969).

P o u l t r y. A study at MacDonald College (Brisson et al., 1950) showed that a ration containing fababeans fed without supplement of fishmeal or equivalent was deficient for optimum body growth and feathering. This deficiency could be corrected by the addition of methionine. Sanz Arias (1963), Blair and Bolton (1968) and Anonymous (1970a) and (1970b) emphasize that addition of methionine in poultry rations is essential, while the general agreement is that this is not needed for ruminants. Blair and Bolton (1968) included up to 30 percent fababeans in rations of 4 - 9 week old broilers successfully. Methionine was added to the rations. For laying hens, a maximum of up to 10 percent fababeans is recommended, (Anonymous, 1970b).

In feeding trials with rats, Nitsan (1970) concludes from the lower utilization of absorbed nitrogen and reduced enzymatic activity in pancreas and intestine, that feeding quality of fababeans is slightly inferior to that of soybeans. He suggests that fababeans may be used in the diets of rats replacing soybeans if shelled and at sufficiently high levels to compensate for the lower quality. The shells constituted 14 percent by weight in his material.

S i l a g e. More recently, fababeans have been grown in mixtures with various other crops for ensilage. By harvesting the whole crop, yield of DM doubles that of seed yield alone, while the

protein content is halved. It was also found, that digestibility was reduced from 82 to 60 percent. Maximum digestibility is obtained when the pods are well developed and form a high portion of the DM. Also, some varieties may be more suited than others. Calancea et al.(1964) concluded from their experiments that fababeans could be even ensilaged alone if anaerobic conditions were closely maintained during fermentation and preservation. Another form of preservation of whole bean crops is also being investigated, namely natural and artificial drying. The latter process may involve pelleting of the product, (Bond, 1970).

Lonsdale and Taylor (1969) report that food intake and daily live weight gains increased from 0.44 kg/head of cattle with maize silage alone to 0.74 kg/head with a mixture of maize and fababeans. In this mixture the fababeans made up 29 percent of the total DM. By increasing the portion of fababeans to 57 percent, weight gains rose to 0.97 kg/head.

Görlitz (1963) obtained superior yields with a mixture of fababeans and maize than with either vetches, lupines or peas. The best seed rate was 60 kg/ha maize and 80 kg/ha beans. A similar trend was observed by Robinson (1968), whereby fababeans and oats outyielded oats alone in protein per unit area by approx. 170 kg/ha, over several years.

F a v i s m. The term favism designates an acute hemolitic anemia due to the ingestion of broad beans or inhalation of broad bean pollen. Favic crisis were found of moderate intensity after ingestion of cooked or dried beans but severe after consumption of

fresh raw beans. Since there is no evidence that fababeans differ qualitatively from broad beans a brief review of the problem is given here based on a paper by Mager et al. (1969).

The disease has usually a benign outcome on adults and the fatality rate of 6 - 8 percent in children less than 6 years of age has now been greatly reduced. Favism is prevalent in insular regions of the Mediterranean area. In Europe outside the Mediterranean coast and in America favism is extremely rare.

The destruction of red blood cells in humans is thought to be an enzymatic deficiency controlled by a gene located on the X-chromosome. The fact that only certain genotypes are susceptible to favism explains the high incidence of the disease in insular and secluded regions with a high degree of intermarriage. Favism is quite common amongst Sardinians, some oriental Jewish communities and Negroes from the Congo (Kinshasa).

The definitive identity of the causative agent remains to be resolved. It is assumed that pyrimidine derivatives such as vicine and covicine are involved.

1.10 Agronomic Characters

S e e d Y i e l d s. It is said (North, 1969) that seed yields of fababeans are notoriously variable and this has been a major obstacle to wider distribution of the crop. Reliable data on this aspect are not available. However, it is common practice to plant beans

on fields not suitable for other crops or as a break crop in the last position in the rotation cycle. Overall statistics may thus be biased and will not reflect the true yielding potential of fababeans. Table 1.10.1 gives acreage and seed yields of fababeans and yields of soft wheat in five European countries (Presber, 1972, l.c.).

Table 1.10.1 Acreage and seed yield production of fababeans and soft wheat in 5 European countries.

	Fababean Acreage 1971/72 000 acres	Seed Yield in qu/ha					
		1969		1970		1971	
		Fabab.	Wheat	Fabab.	Wheat	Fabab.	Wheat
F.R.Germany	48.9	31.0	40.2	31.1	37.9	30.3	46.2
France	41.3	19.9	36.1	21.4	34.7	21.0	39.1
Italy	794.4	11.0	25.6	10.4	27.5	11.0	28.8
Belgium	3.0	30.0	38.2	25.3	39.0	29.4	45.2
Luxemburg	1.0	20.0	34.5	18.0	24.5	29.4	32.0

The table shows consistently lower yields for fababeans as compared to soft wheat, whereas the year to year fluctuation for both crops is relatively small. Lowest yields for fababeans were recorded in Italy, which also showed lowest yields for wheat. It must be noted however, that Italy has with 794 400 acres by far the biggest acreage.

In Britain, beans were grown on 88 400 ha (221 000 acres) in 1969/70 with an overall mean yield of 28 qu/ha, (Presber, 1972).

Parsche (1969) gives mean yield figures for fababeans of 7 provinces of West Germany, the acreage ranging from 3 500 to 25 000 acres in the respective provinces (Table 1.10.2).

Table 1.10.2 Fababean mean yield figures for 7 provinces of West Germany in 1967 and 1968.

	Seed Yield in qu/ha	
	1967	1968
Schleswig Holstein	32.2	33.6
Niedersachsen	30.1	30.9
Nordrhein Westfalen	31.8	31.8
Hessen	33.5	34.1
Rheinland Pfalz	36.4	34.1
Baden-Württemberg	29.0	28.3
Bayern	30.8	30.7

It has been shown by Hanna and Hayes (1966) that the important yield components were inherited in an additive fashion. This holds especially true for seeds/plant and weight of seeds/plant. Kambal (1969 b)also found that Pods/plant were highly correlated with seed yield and hence could be used as a selection criterion. In contrast, Bond (1969) indicates that increasing one yield component results in a decrease of another.

M a t u r i t y. Due to their late maturity, flowering and pod setting starts late in the season, often during hot and dry weather. El Nadi (1969) has shown that flower and pod shedding is greatly increased during times of water stress. Therefore, selection for earlier maturity is a major objective in most breeding programs, (Sjödin and Ellerström, 1968; Bond, 1969). With one exception, all earlier varieties bred so far were more disease susceptible and yielded lower; the variety Strube is quite early, fairly resistant to Ascochyta fabae and yields well, (Bond, 1969).

Incorporation of determinate flowering structure is another possibility to shorten the life cycle. As Bond (1969) points out, plants having determinate flowers are found only in exotic, low yielding forms. New material may become available since mutants have been found in radiated material showing determinate flower structure. Earliness and even ripening is greatly improved in these types. However, stem elongation terminates between the third and fourth flower cluster and thus plants do not attain usual height and seed yield. Incorporating this gene in different genetic background did yield a taller plant with improved seed set, (Sjödin, 1971).

Theoretically, earliness and even ripening may be achieved, but plasticity of yield components and range of adaptation may be lost at the same time. A plant with determinate flower structure would develop in a sequential pattern: number of pods, number of seeds per pod and weight per seed would develop in this order, (Adams, 1967). In order to provide a buffer and enough sink capacity, this would then mean selecting big sized seeds,(Donald, 1968).

Another way to hasten maturity would be the selection of non-nodulating types. The steady supply of nitrogen through nodulation keeps the plant growing continuously into late summer, (Anonymous, 1970a). In the absence of rhizobias nitrogen fertilizer could be applied at times and amounts condusive to early maturity.

B r a n c h i n g. Existing varieties are adapted to West-European conditions and branch little. Consequently, seed rates have to be high which in turn makes plantings costly. Branching cultivars reduce seeding costs but also would compensate to some extent for poor establishment. Moreover, under dryer growing conditions, establishment of "early" yield components such as branches seems beneficial. Under moisture stress metabolites are translocated from branches to the main shoot, thus providing a reservoir, (MacKey, 1966). This is in contrast to the model plant put forth by Donald (1968), who suggests for cereals a uniculm variety, e.i. no tillers. Some of the exotic types which branch profusely are also wrinkle-podded and do not shatter, (Bond, 1969).

S e l f i n g - O u t c r o s s i n g. The peculiar characteristics of fababeans, being crosspollinated originally but showing selfpollination up to 70 percent if pollinators are lacking, is thought of being one reason for variability of seed yields. It was found that certain Mediterranean types show almost complete self- or autofertility, (Kambal, 1969a; Bond, 1969). An autofertile plant would be independent of insect-pollinators and weather conditions and consequently more reliable in seed set and grain yield.

On the contrary, the outcrossing character of fababeans could be used to break up linkage groups through several cycles of intercrossing and provide new recombinants, (Miller and Rawlings, 1967).

S y n t h e t i c s. Synthetic varieties have been produced and tested, but gains were not significantly above conventional cultivars, (Bond, 1969). Drayner (1956) reports that in her material there was too much inbreeding, which could be one reason for insufficient yield gains. The performance of synthetics did however improve up to F_3. The British list of recommended varieties for 1972 names one variety as being a synthetic: cult. Throws M.S., a winter type.

C o m m e r c i a l H y b r i d s. Plant breeders have been able to achieve only limited advances in seed yields of fababeans, (Bond et al., 1964). These authors propose radical changes such as exploitation of hybrid vigour through genetic or plasmatic male sterility and matching restorer lines, (Bond et al., 1964a; 1964b; 1966a; 1966b; Bond, 1967). In good combinations, heterotic effects seem to be substantial and increases of 20 (Bond, 1969) to 80 percent (Martyanova, 1967) over selfed seed have been reported. However, seed costs are up to 50 percent higher. So far, no hybrid variety has been marketed. It may be possible to reduce planting costs by use of F_2 seed, since some hybrids reportedly have sufficient residue of vigour, (Bond, 1969).

1.11 Marketing

The information on marketing of fababeans is rather scarce. More recent data are only available from Britain, where a Government subsidy was paid in order to stimulate production, but has been dropped recently.

Hayward (1969) gives breakdown figures for the 1967 crop of 127 000 tons in U.K.:

Used on farms	55%
Pigeon trade	15%
Export	15%
Compounding industry	15%

Recently reported prices (Anonymous, 1970a) are around £ 64.00 per ton.

The export industry in U.K. offers higher prices than feed manufacturers, due to the good demand in Western Europe. Dried legume crops imported in the Common Market face only a 7.2 percent ad valorem tariff, which makes cost of fababeans equal to cereals, but gives the extra protein as a bonus. Most of the exported ware goes into the feed industry, little is used as pigeon feed. In Germany, fababeans are included in sausages, (Hebblethwaite and Davies, 1971).

Large feed manufacturers are reluctant in accepting fababeans. Several reasons can be named. Under present production figures, fababeans constitute only 2.4 percent of the possible protein supply. Furthermore, this small supply also lacks continuity, due

to inconsistent seed yields mainly. Feed manufacturers will not change their already complicated system to accomodate small and unreliable quantities, (Hebblethwaite and Davies, 1971).

Other reasons are more of mechanical nature. Beans are often stored at moisture contents above 14 percent. At 18 percent moisture, beans cannot be milled since they form a paste rather than flour. It is also said that bean flour cakes with compression when held in large bulks, especially when stored above optimum moisture content. Danger of rancidity is greatly increased when beans are ground above 14 to 15 percent moisture content, (Anonymous, 1970a).

2. MATERIALS AND METHODS

2.1 Variety Trials

1971 Yield Trials. Trials were planted at three locations in Manitoba (Winnipeg, Baldur and Dauphin) and three locations in Saskatchewan (Melfort, Swift Current and Indian Head). The trials at Dauphin and Baldur were incorporated into the Regional Testing Program; the trials in Saskatchewan were conducted by CDA Research Stations.

Each trial comprised 15 varieties in a randomized block design with 3 replicates. The varieties tested and their origin are listed in Table 2.1.1. A plot consisted of 3 rows, 5.55 m long (rod row). Spacing was 30 cm between rows and 45 cm between plots. Trials were planted as early as possible with cereal planters adjusted to maximum depth, resulting in a depth of planting of approx. 2.5 to 4 cm.

Seed rate was 80 viable seeds per rod row for all varieties. Based on a thousand seed weight of 350 g (Ackerperle), this amounts to 168 kg/ha (150 lbs/acre). Glenlea wheat was planted for comparison at 2 locations with a seed rate of 300 seeds per rod row (78.5 kg/ha).

Seeds were inoculated prior to planting. Techniques used are described under inoculation trials.

Table 2.1.1. Fababean cult. tested in yield trials, and their origin

Cultivar	Origin
Varieties tested in 1971	
Ascott	Picard, France
Columba	" "
Primeperle	" "
Fribo	Kleinwanzlebener Saatzucht, Germany
Herz Freya	" " "
Kleine Thüringer	" " "
Dornburger	Lembke, Germany
Schladener	Breustedt, Germany
Maris Beaver	Plant Breeding Institut, Cambridge,Engl.
Nadwislanski	Krakowska Hodowla Roslin, Poland
Major	" " " "
B F 12/2	Hudieba Research Station, Sudan
Baladi	" " " "
Primus	University of Minnesota
Windsor Broad Bean	McKenzie,Co., Winnipeg
Varieties tested in 1971 and 1972	
Erfordia	Lembke, Germany
Ackerperle	Franck, Germany
Diana	Breustedt, Germany
Wieselburger Kleinkörnige	Wieselburg, Austria
Maris Bead	Plant Breeding Institut, Cambridge,Engl.
Fioletowy	Krakowska Hodowla Roslin, Poland
Pavane	Picard, France
Strubes	" "
Glenlea Wheat	University of Manitoba

The rates of fertilizer applied varied; rates are given in Appendix I, along with planting dates, harvesting dates, precipitation and soil types. Weeds were controlled in all experiments by hand-howing.

Flowering was determined when the first buds opened on a majority of the plants. Maturity was noted when two thirds of the pods on the main shoot turned black and the seeds were hard. Plant height is recorded as the total length above ground.

Harvesting procedures were similar for all trials. At maturity, center rows (or all 3 rows in some cases) were cut by sickle, bundled and stooked or immediately bagged and artificially dried. After a period of 1 to 2 weeks to allow for drying the beans were threshed with a Hege plot combine. Cylinder speed was greatly reduced and concaves opened wide to avoid breakage.

Seed weight was determined on 200 seeds per variety. Protein was determined on a composite sample for each variety and location on a dry matter basis, N x 6.25; bushel weight was measured on the same samples.

1 9 7 2 Y i e l d T r i a l s. The number of entries was reduced to 10 including Glenlea wheat and the number of locations was increased to 25; 8 in Manitoba, 5 in Saskatchewan, 4 in Alberta, 2 in Ontario, 1 in Quebec and 5 in the Maritime Provinces. The trials were combined with the Regional Testing Program in Manitoba; cooperating CDA Research Stations and Universities conducted the trials in the other provinces, (App.I).

Plot size was increased to 4 rows, with the 2 center rows harvested for yield determinations. All other details remained unchanged.

2.2 Seed Rate and Spacing Trials

To determine optimum plant populations, experiments were conducted at the University in 1971 and 1972, using the cultivar Ackerperle. This is a small seeded type with a thousand seed weight of approx. 350 g. The experiment in 1971 consisted of 4 seed rates, 140, 180, 220 and 260 kg/ha at row spacings of 15 and 30 cm. In 1972, two additional rates were tested (60 and 100 kg/ha). All treatments were inoculated as described later. The experiments were planted in a split-plot design, with spacings being the main-plots and seed rates the sub-plots. Plots were 5 m long and consisted of either 6 rows at 15 cm spacing or 3 rows at 30 cm spacing, thus always totalling 90 cm in width. In both years the tests consisted of six replicates. In 1971, seed yield was taken from the center rows only, whereas in 1972 all rows were harvested.

The test site soil is a Red River clay with a high water retention capacity. The April to July precipitation totalled 10.95 inches in 1971 and 5.52 inches in 1972. Trials were planted on summer fallow without fertilizer application.

Bushel weight and seed weight were determined on 3 composite samples, while protein content was determined on 2 composite samples from each treatment. For the determination of yield components,

15 plants were taken per plot from the center rows in 1971 and 10 plants per plot in 1972. Pods per plant were counted, the plants threshed individually and seed yield per plant determined. Seed weight per pod was calculated by dividing seed weight per plant by the number of pods per plant.

2.3 Survey of Exotic Germplasm

From a world collection increased and screened in 1971, sufficient seed was available for yield trials at 3 locations in Manitoba in 1972, (Winnipeg, Glenlea and Teulon). In all, 36 lines were entered including check varieties. The layout was a randomized block design with 3 replicates. A plot consisted of 1 row 5.55 m long, plots were 0.60 m apart. Seed rate was reduced to 70 seeds per row giving a total of 140 kg/ha. The entries in these trials had in general smaller seeds, seed weight ranging from 200 to 350 g per thousand. Other procedures were similar to those described for the yield trials. The varieties included are listed in Table 5.2.

2.4 Inoculation Trials and Harvesting Experiments

C a r b e r r y 1 9 7 1. In order to determine the effect of specific Rhizobia strains on nitrogen fixation, several inoculants were aquired in 1971 from the Radicin Institut, Iserlohn,Germany and from the Nitragin Company in Milwaukee, USA. A trial was planted in the Carberry area using the cultivar Ackerperle, on land which had

not grown peas recently. A plot consisted of 3 rows, 30 cm apart, 5.55 m long. The trial was planted as a random plot design with 3 replicates. The center row was harvested and protein was determined on a composite sample of each treatment.

The inoculums were applied partly in pelleted form and partly as powder, mixed with the seed. A third form of application, used in all other trials was as follows: coarsely cracked wheat was moistened until a friable mass was obtained. The inoculum was then mixed with the wheat and for each row one teaspoon full of this mixture was placed in the seeder with the seed. The rate applied was approx. three times the recommended rate to ensure sufficient inoculation. For direct coating, a slurry was prepared of water, inoculum and a sticker; preparations were made just prior to planting.

In 1972, the effect of inoculum was estimated in the standard yield trial. Ackerperle was included twice in the test, one entry receiving no inoculum; all other entries were inoculated. The inoculum used was strain 175 FI, specific for fababeans, supplied by the Nitragin Co., Milwaukee. All cooperators were supplied with this inoculum.

H a r v e s t i n g E x p e r i m e n t s. To determine optimum cutting time, plants from an increase field Ackerperle were classified into 4 groups according to maturity: very green, green, near ripe and ripe at the time of swathing. From these groups, small samples of seed were shelled out for moisture determination; the

remainder of the plants were stooked and air dryed. After completion of drying, plants were threshed and bushel weight and thousand seed weight determined.

In addition, an increase plot of the cultivar Ackerperle was swathed into 5 strips at intervalls of 4 days, starting at August 28 through September 11, 1972. Seed samples were shelled out at the time of cutting for moisture determination. All strips were threshed October 20 and bushel weight and thousand seed weight determined on representative samples.

2.5 Fertilizer Placement Trial

The large seeds of fababeans need a comparatively long time to imbibe sufficient moisture to permit germination and emergence. High salt concentration in the soil solution in close proximity to the seeds caused by combined application of seeds and fertilizer could thus be especially harmful. Increasing rates (0, 11, 16.5, 22, 27.5 and 33 kg/ha N and 0, 48, 72, 96, 120, and 144 kg/ha P_2O_5) of the compound fertilizer 11 - 48 - 0 were applied together with the seed of cult. Ackerperle and in direct contact with it; treatments received no inoculum. The trial was planted at Teulon as a randomized block experiment. A plot consisted of 4 rows with rows 30 cm apart; seed rate was 80 seeds per row, total plot length 5.55 m. Each treatment was replicated three times. For yield determinations, all 4 rows were harvested.

2.6 Disease Trial

The leaf and pod spot disease of fababeans, Ascochyta fabae, can be devastating. Samples of diseased seeds were therefore treated with 50% a.i. Captan to check the effectiveness of control of this disease. The trial was planted at Winnipeg in 1972. A plot consisted of one row 2.5m long in which 30 seeds were planted. Seeds were selected by hand: for treatment no. 1 only the soundest seeds were selected; the same class of seeds was used for treatment no. 2 but treated with Captan. Only diseased seeds were planted in treatments no. 3 and 4, but treatment no. 3 received a seed dressing with 50% Captan prior to planting.

PART II

RESULTS AND DISCUSSION

3. Y I E L D T R I A L S

3.1 Seed Yield Production

M a n i t o b a. Eleven yield trials were conducted, three in 1971 and eight in 1972 (Table 3.1.1.). The mean yields attained were 39.2 qu/ha in 1971 and 32.2 qu/ha in 1972. The utility wheat variety was included in two of the trials in 1971 and in all trials in 1972. The average yield of Glenlea was 32.1 qu/ha in 1971 or 7 qu/ha below the overall mean. In 1972 the Glenlea average yield was 36.6 qu/ha or 1.7 qu/ha above the best bean variety. But only in one case was the Glenlea yield significantly above the best bean.

Of the 15 varieties tested in 1971 Primeperle and Columba were the lowest yielding. The varieties Erfordia, Pavane, Strubes, Herz Freya, Fribo and Schladener were similar in yield. They are all relatively large seeded and only the first three were retained for 1972 testing. Of the smaller seeded varieties Ackerperle, Diana and Kleinkörnige were retained for further testing. In addition to yielding ability, seed size and maturity were also considered in deciding which varieties to further test. The varieties Maris Bead and Fioletowy were added to the 1972 tests because of the production of Maris Bead in the Maritimes and the small black seed character of Fioletowy.

As indicated in Table 3.1.1 favorable results were obtained at all Manitoba sites in 1972 except Morris and Glenlea. These loca-

Table 3.1.1 Seed yields (qu/ha) of fababean trials conducted in Manitoba in 1971 and 1972

Variety/ Location	Seed Yields (qu/ha)												
	1971				1972								
	Winnipeg	Baldur	Dauphin	Mean	Winnipeg	Glenlea	Baldur	Teulon	Morris	Dauphin	Brandon	Morden	Mean
Erfordia	66.2	36.4	30.0	44.2	53.7	15.7	40.1	31.8	14.9	46.3	30.5	46.5	34.9
Ackerperle No In.	-	-	-	-	45.2*	10.4*	28.6	28.1	10.7	25.2	23.9	46.8	27.4
Ackerperle	60.9	37.7	19.9	39.5	54.4	16.5	36.0	29.1	13.2	39.5	27.4	42.9	32.4
Diana	47.6	37.6	30.1	38.4	45.4	13.3	39.5	31.6	12.9	40.8	32.1	39.1	31.8
Fioletowy	-	-	-	-	48.2	14.1	28.6	31.1	16.5	37.7	28.6	46.1	31.4
Kleinkörnige	70.2	37.5	23.5	43.7	48.8	10.7	29.9	30.8	16.0	38.0	36.3	49.2	32.5
Maris Bead	-	-	-	-	47.1	13.0	29.5	32.7	14.3	34.1	18.2	44.6	29.2
Pavane	62.4	44.0	27.2	44.5	47.3	13.8	37.0	30.2	16.9	48.3	30.1	53.2	34.6
Strubes	46.9	45.2	32.8	41.6	46.4	16.9	37.3	29.1	11.0	45.5	30.2	38.8	31.9
Glenlea Wheat	38.3	-	25.9	32.1	35.3	14.5	36.7	36.2	35.1	43.3	46.4	45.1	36.6
Ascott	55.0	37.5	22.7	38.4									
Columba	50.0	31.2	22.0	34.4									
Dornburger	57.4	34.7	25.5	39.2									
Fribo	58.2	36.8	24.0	39.7									
Herz Freya	55.9	39.6	30.9	42.1									
Kl.Thüringer	54.5	32.3	28.9	38.6									
Primus	48.6	40.3	26.2	38.4									
Primeperle	43.7	35.0	19.9	32.9									
Schladener	48.3	42.5	28.6	39.8									
Mean	54.0	38.0	25.0	39.2	47.2	13.9	34.4	31.1	16.1	39.9	30.4	45.2	32.2
L.S.D. P=0.05	13.9	N.S.	N.S.		6.5	N.S.	N.S.	N.S.	5.8	8.2	12.6	6.6	
0.01	N.S.	N.S.	N.S.		12.2	N.S.	N.S.	N.S.	10.8	15.3	N.S.	N.S.	

* accidentally inoculated

tions are both on Red River clay and had very little rainfall (Appendix I). The low yields are probably a combination of drought at critical growth stages and the heavy clay soil which may be very compact limiting aeration and root development. It was noted by other workers (Sebilotte, 1963; North, 1969; Ellis, 1969) that faba-beans are sensitive to soil compaction.

No significant yield differences occured in five of the eight tests. However, two varieties, Erfordia and Pavane performed well in all experiments. Erfordia ranks first on the average and yielded above the location mean except at Baldur and Morris; Pavane ranks second on the average and shows slightly more variability.

Little difference exists between Strubes, Kleinkörnige, Ackerperle and Diana, all of which show more fluctuation in their performance. Fioletowy and Maris Bead rank lowest almost consistently (apart from non-inoculated Ackerperle, which will be dealt with later).

S a s k a t c h e w a n. In all, 8 experiments were conducted in Saskatchewan in the two years, but only seven were harvested due to a complete failure at Scott in 1972 caused by drought. The two years differ markedly by 12 qu/ha (Table 3.1.2) in overall yield (1971 = 22.3 qu/ha; 1972 = 34.8 qu/ha). Although little difference exists between the two years in total precipitation during the growth period (App.I), 1971 was characterized by a dry spell in April - May. Precipitation recorded at Indian Head was 0.88, 0.47 and 4.79 inches for April, May and June respectively. A similar pattern was recorded for Swift Current and Melfort. This does not necessarily mean that

Table 3.1.2 Seed yields (qu/ha) of fababean trials conducted in Saskatchewan in 1971 and 1972

Variety/ Location	Seed Yields (qu/ha)								
	1971				1972				
	Swift Current	Melfort	Ind. Head	Mean	Swift Current	Melfort	Ind. Head	Saskatoon	Mean
Erfordia	28.8	29.2	21.7	26.6	37.0	34.2	31.3	43.5	36.5
Ackerperle No In.	-	-	-	-	31.6	28.8	25.8	41.3	31.9
Ackerperle	21.9	22.0	15.3	19.7	36.1	30.5	28.0	44.8	34.8
Diana	24.3	21.8	22.5	22.9	36.8	31.7	28.5	43.9	35.2
Fioletowy	-	-	-	-	32.5	32.6	29.4	40.1	33.6
Kleinkörnige	21.0	25.0	14.4	20.1	31.5	33.1	27.0	40.6	33.0
Maris Bead	-	-	-	-	32.1	30.3	26.2	30.9	29.9
Pavane	25.3	26.2	21.2	24.2	40.7	33.2	29.3	44.7	37.0
Strubes	26.7	29.3	21.1	25.7	37.0	32.0	29.7	38.3	34.2
Glenlea Wheat	-	-	-	-	43.0	36.8	34.0	54.4	42.0
Ascott	21.5	27.8	17.3	22.0					
Columba	19.2	20.7	17.9	19.2					
Dornburger	23.0	21.7	16.2	20.3					
Fribo	25.0	31.3	18.5	24.9					
Herz Freya	25.8	29.5	18.8	24.7					
Kl.Thüringer	26.6	24.9	19.7	23.7					
Primus	22.8	23.1	12.5	19.5					
Primeperle	18.6	23.2	11.3	17.7					
Schladener	23.2	28.4	20.5	24.0					
Mean	23.6	25.6	17.3	22.3	35.8	32.3	28.9	42.3	34.8
L.S.D. P=0.05	4.3	5.3	5.1		5.1	N.S.	4.2	7.8	
0.01	N.S.	N.S.	N.S.		9.5	N.S.	N.S.	10.7	

fababeans are extremely susceptible to dry conditions in the early growth stage, since low rainfalls in April and May were recorded at other locations also without seriously depressing yields. Many other factors such as temperature, evaporation, water retention capacity of the soil and level of water table will affect growth rate. It was however noted by Jones (1963) for broad beans, that early drought is likely to be a greater hazard than waterlogging.

The trial at Saskatoon conducted under irrigation achieved the overall highest yields.

A comparison to Glenlea wheat is only possible for 1972. On the average, Glenlea outyielded the top fababean variety by a significant amount of 5 qu/ha. Its superiority is clearly established at Swift Current and Saskatoon.

As to varietal differences, a similar pattern exists to that of Manitoba; Pavane, Erfordia and Strubes (in this order) are ranked highest, followed by Diana and Ackerperle. Although yield differences were frequently not significant the appearance of the same varieties at the top of the yield ranking can not be ignored.

The variety Kleinkörnige does not fit the pattern established in Manitoba: in 6 out of the seven trials this variety is below the location-mean yield. Fioletowy and Maris Bead also produced consistently below average yields. This statement also applies to Columba and Primeperle of the 1971 group. None of the other varieties in this 1971 group did outstandingly well, but some are probably close to the yield potential of Erfordia (Fribo, Schladener, Herz Freya).

A l b e r t a. In all, 4 trials were planted in Alberta. The trial at Lacombe was blackened by frost long before pods were filled, thus only 3 trials were harvested and results are given in Table 3.1.3. The overall mean yield achieved is exceptionally high with 47.9 qu/ha. This is mainly due to the high yields recorded in the Peace River Valley (Beaverlodge), although early drought (which was corrected by irrigation) and frost, snow and rain plagued this trial. The information available in this province is more limited than of others, but it does indicate that fababeans can be grown there and will mature.

Glenlea behaved rather erratic for no obvious reasons at Lethbridge and Beaverlodge: at Lethbridge yields are significantly below and at Beaverlodge significantly above bean yields. Apart from this, varietal behaviour is rather similar to that of the other Western provinces: Erfordia, Pavane and Strubes are in the top group, followed by Diana and Ackerperle.

Maris Bead again ranks consistently below all the station means, as does Fioletowy and Kleinkörnige.

E a s t e r n C a n a d a and M a r i t i m e P r o v i n c e s. Eight trials were conducted in 1972 and results are reported in Table 3.1.4. The overall mean yield of 34.5 qu/ha compares well with Western yields, although higher yields were expected due to a longer growing season and better moisture supply. While rainfall during the critical

Table 3.1.3 Seed yields (qu/ha) of fababean trials conducted in Alberta in 1972

Variety/ Location	Seed Yields (qu/ha)			
	Edmonton	Lethbridge	Beaverlodge	Mean
Erfordia	41.3	66.1	59.2	55.5
Ackerperle, No In.	33.1	56.5	39.7	43.1
Ackerperle	40.0	52.6	44.7	45.8
Diana	37.1	57.1	50.7	48.3
Fioletowy	37.2	48.7	50.4	45.4
Kleinkörnige	36.6	48.8	47.7	44.4
Maris Bead	33.9	42.3	47.9	41.4
Pavane	40.6	58.6	60.4	53.2
Strubes	43.3	51.9	53.8	49.7
Glenlea Wheat	39.5	20.8	96.3	52.2
Mean	38.3	50.3	55.1	47.9
L.S.D. P=0.05	N.S.	12.4	21.5	
0.01	N.S.	23.1	40.1	

Table 3.1.4 Seed yields (qu/ha) of fababean trials conducted in Eastern Canada and the Maritime Provinces in 1972

Variety/ Location	Seed Yields (qu/ha)								
	Kempt-ville, Ont.	Otta-wa Ont.	Que-bec P.Q.	Tru-ro N.S.	Kent-ville N.S.	Charlot-tetown P.E.I.	Frederic-town N.B.	Nap-pan N.S.	Mean
Erfordia	33.2	39.6	39.1	34.3	41.0	32.5	38.2	38.0	37.0
Ackerperle, No In.	30.1	37.6	28.6	33.0	35.1	21.4	40.3	36.6	32.8
Ackerperle	33.7	38.3	26.9	30.9	36.0	29.8	36.8	38.5	33.9
Diana	28.5	38.0	37.2	36.0	36.6	28.5	40.3	40.6	35.7
Fioletowy	35.6	43.6	35.2	30.8	34.7	30.5	40.5	38.3	36.1
Kleinkörnige	40.5	48.0	37.0	33.8	38.6	27.0	37.3	36.2	37.3
Maris Bead	30.9	30.0	29.0	31.2	29.5	18.7	33.1	29.6	29.0
Pavane	33.3	47.8	36.5	30.3	41.1	28.5	37.8	47.5	37.8
Strubes	30.6	37.6	33.9	30.2	37.9	31.2	42.2	38.2	35.2
Glenlea Wheat	-	-	30.0	24.6	20.0	30.8	41.5	30.3	29.5
Mean	32.9	40.1	33.3	31.5	35.0	27.9	38.8	37.4	34.5
L.S.D. P=0.05	N.S.	8.2	N.S.	N.S.	N.S.	8.1	N.S.	8.7	
0.01	N.S.	15.3	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	

months April through July rarely exceeded 10 inches in the Western Provinces (average 7.87), 14.76 inches occurred on the average in the East and the Maritimes. There is however remarkably little variation amongst station mean yields, as compared to Western Canada. Moreover, the wheat check ranks lowest in overall yield and is below all the station means (bird damage at Ottawa and failure to plant at Kemptville account for the 2 missing values).

Ranking of bean cultivars based on the overall mean is also slightly different to that of other provinces. Kleinkörnige ranks among the top group along with Pavane and Erfordia, followed by Fioletowy. These deviations originate mainly in Ontario. In the middle group are Diana, Strubes and Ackerperle. Maris Bead, however, again occupies the last position, being significantly below Erfordia at 3 out of the 8 locations.

C o n c l u s i o n s. Two years results from 31 experiments fall far short of an adequate evaluation of fababeans, under environmental conditions as variable as experienced in Canada. However, the fact that only 2 trials out of these 31 were a complete failure (Lacombe and Scott), and only 3 more resulted in unsatisfactory yields (Indian Head 1971; Glenlea and Morris 1972) justifies some optimism. The total average over the 2 years and 29 trials, amounts to the respectable yield of 35.1 qu/ha or 3130 lbs/acre. As a comparison, the longtime average of field peas in Canada is reported to be 14 qu/ha (Miller, 1972). The yields obtained in the 2 year period are comparable to those experienced in Western Europe (Presber, 1972 l.c.).

Although few significant yield differences exist between the 6 most extensively tested varieties (e.i. Erfordia, Pavane, Strubes, Ackerperle, Diana, Kleinkörnige), the ranking between years and among provinces in the West is remarkably constant with Erfordia, Pavane and Strubes(usually in this order) being in top positions. The second group comprises Ackerperle, Diana and Kleinkörnige. This grouping coincides with the seed size: the higher yielding group having the bigger seeds. In the East, Kleinkörnige and Diana improved their standings, ranking second and fourth on the average.

The two varieties tested in 1972 only, Maris Bead and Fioletowy, showed an overall inferior performance, especially Maris Bead. Fioletowy showed greater potential in the East and in the Maritime Provinces.

Of the varieties tested in 1971 at 6 locations in the West, only Fribo, Herz Freya and Schladener need to be mentioned. These varieties do not exceed Erfordia in yield, but due to their yield potential and desirable agronomic characters may warrant further testing.

An elegant and sensitive method to describe phenotypic stability in a quantitative fashion was divised by Finlay and Wilkinson (1963). According to this method all seed yield data (variety means and site means) were transformed to a $\log_{10}$ - scale which induces linearity; individual varieties are then regressed to location means. The varieties with general adaptibility, that is

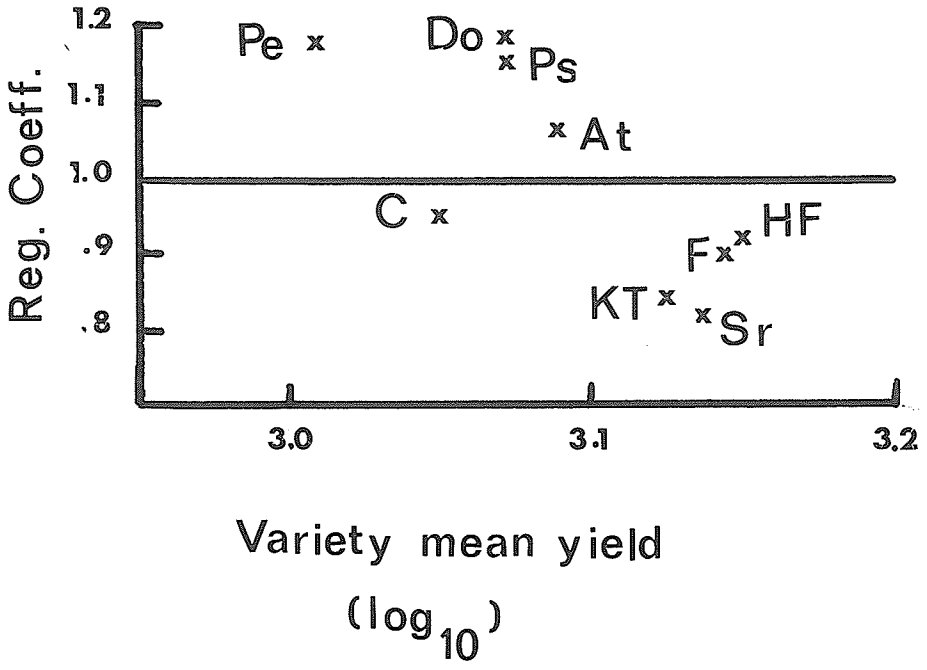
highest mean yields over all environments, possess above average phenotypic stability (b = approx. 1.0). Regression values above 1 describe varieties with increasing sensitivity to environmental changes and specifity for high yielding environments; regression values below 1 provide a measure of greater resistance to environmental changes and therefore increasing specifity of adaptibility to low yielding environments.

In Figures 3.1.1 and 3.1.2 the variety mean yields of all stations and years are plotted vs. their regression coefficient. In general, these diagrams graphically substantiate our variety evaluation. Little more can be said about varieties tested in 1971 only except that Herz Freya, Fribo and Schladener gave the highest overall mean yield and are reasonably well adapted to low yielding environments (b = below 1).

Figure 3.1.2 shows the average mean yield of Glenlea over all locations. It is better adapted to low yielding environments than any of the fababeans, indicating above average phenotypic stability (b = 0.52).

To the contrary, Maris Bead has a low average mean yield associated with a b = 1.24. This indicates the variety is more adapted to favourable environments, that is low general adaptation; Kleinkörnige shows the same overall tendency, but has a higher yield potential. Little differences exist in general adaptation between most of the other varieties having regression coefficients close to 1. However, Erfordia and Pavane show highest overall mean yield again evidencing their superior adaptation.

Fig. 3.1.1. Variety means of 6 locations tested in 1971, plotted vs. their regression coefficients.

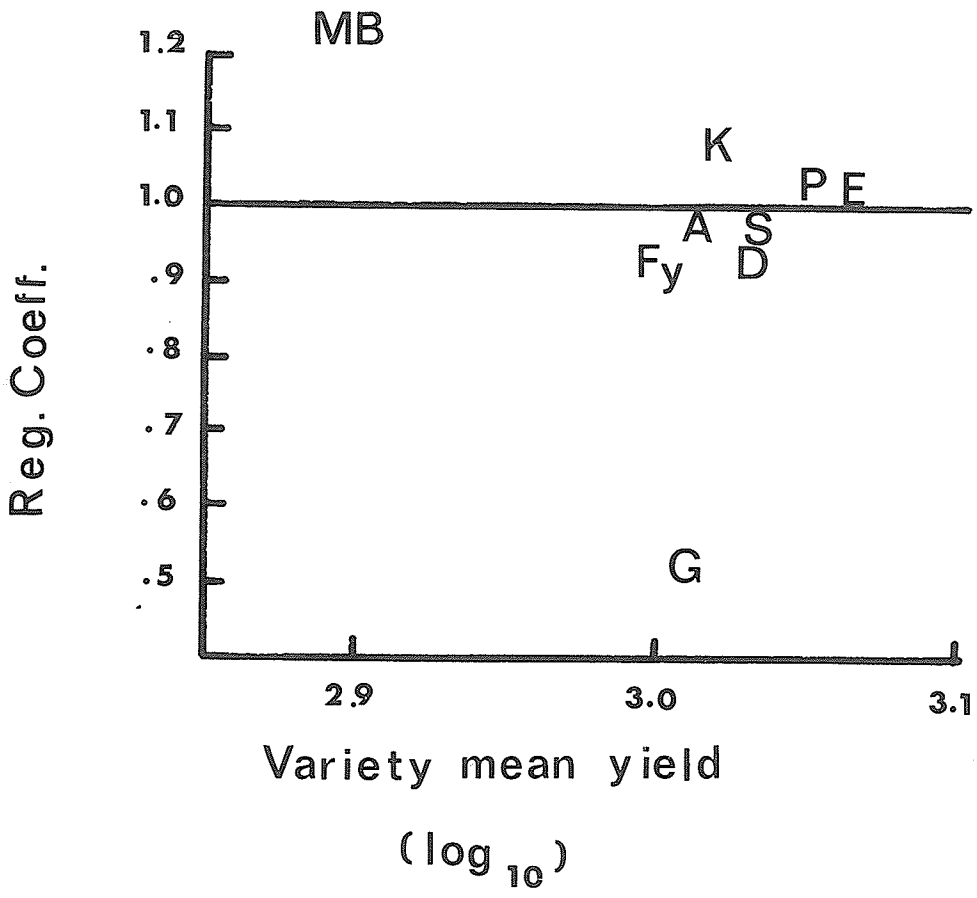


(Pe-Primeperle, Do-Dornburger, Ps-Primus, At-Ascott, C-Columba, HF-Herz Freya, F-Fribo, KT-Kleine Thüringer, Sr-Schladener)

A combined analysis of variance conducted independently on both groups presented in Figs. 3.1.1 and 3.1.2 indicated significant variety x location interaction (App.II), which supports the findings born out in Finlays and Wilkinsons method.

An attempt made to correlate total amount of rainfall from April to July to seed yield obtained was bound to fail:too many other variables affect moisture available to plants, such as temperature, soil water retention capacity, soil structure etc. Thus at 5 inches precipitation April-July, we found very high yields (Winnipeg, 1972; Melfort, 1972; Beaverlodge, 1972) and low yields (Glenlea, 1972; Morris, 1972) (App.I). At higher levels of precipitation as prevalent in the East, a saturation point is reached and moisture availability is most probably not a limiting factor. As far as the West is concerned, the data obtained could be interpreted that at both, high and low rainfall, good seed yields can be achieved but factors such as soil type and others mentioned above, as well as distribution of precipitation may be of equal importance. Moreover, early plantings which better utilize early available moisture generally resulted in higher yields.

Fig. 3.1.2. Variety means of 29 locations * tested over two years, plotted vs. their regression coefficients.



* , Maris Bead and Fioletowy 23, Glenlea 21 locations, respectively.
(A-Ackerperle, D-Diana, E-Erfordia, Fy-Fyoletowy, K-Kleinkörnige, MB-Maris Bead, P-Pavane, S-Strube, G-Glenlea)

3.2 Agronomic Characters

E m e r g e n c e and S e e d l i n g V i g o u r. Initial establishment is slow as compared to cereals. In the trials Glenlea wheat usually emerged in less than 10 days whereas fababeans required 2 weeks or more for emergence. In 1971 emergence was still occurring 4 weeks after planting due to lack of precipitation although sufficient moisture was present for normal emergence of cereals. Once established, growth rate and weed competition is good; plant height reached 70 cm 60 days after planting at Winnipeg in 1971 (Plate 3.2.1 and 3.2.2).

Plate 3.2.1 Fababeans in seedling stage, 30 days after planting

Plate 3.2.2 Fababeans in flowering stage, 60 days after planting

F l o w e r i n g and P o d S e t. Flowering started when plants measured 40 - 60 cm in height; beginning about 40 days after planting. Differences between varieties were considerable (Table 3.2.1).

Table 3.2.1 Plant height, days to flower and days to mature for fababean cultivars tested

Cultivar	Winnipeg				Plant height
	Days to flower		Days to mature		Mean (4 locat.*) ± SE
	1971	1972	1971	1972	cm
Erfordia	54	50	114	107	132 ± 11
Ackerperle	53	46	114	106	127 ± 10
Diana	53	42	112	104	123 ± 11
Fioletowy	55	52	116	107	123 ± 11
Kleinkörnige	54	50	116	107	122 ± 8
Maris Bead	56	54	119	112	132 ± 11
Pavane	52	46	112	102	119 ± 9
Strubes	46	40	112	106	123 ± 7
Glenlea Wheat	57	56	103	105	113 ± 4
Fribo	52		114		140 ± 0
Dornburger	48		114		131 ± 3
Herz Freya	49		112		122 ± 2
Nadwislanski	55		119		127 ± 2
Ascott	52		114		130 ± 3
Kl.Thüringer	53		114		137 ± 2
Major	55		119		125 ± 3
B F 12/2	40		97		65 ± 0
Baladi	40		97		72 ± 2
Columba	57		119		132 ± 2
Schladener	53		114		126 ± 3
Primus	52		112		126 ± 3
Windsor Br.Beans	52		109		105 ± 3
Primeperle	53		112		117 ± 2
Maris Beaver	65		127		137 ± 2

* 2 locations only for Fribo through Maris Beaver

In both years, Strubes was the first and Maris Bead the last to start flowering.

It was noted that, although close to honey bee hives at Winnipeg in both years, (200 m or less), the number of bees in the plots was low; the same observation was reported from Swift Current in 1971. Proximity of rape flowering at the same time may have caused this situation at Winnipeg. As Free (1962) notes, competing crops must be far removed in order to increase the frequency of bee visits. Other pollinators (bumble bees) were almost absent. Although of indeterminate habitat, it was noted that flowering continued only for about 20 days at Winnipeg.

Of the six to eight flowers in a cluster (Plate 3.2.3) seldom more than three set seed; others aborted at various stages and sometimes even whole clusters. This has been observed by other workers (Rowlands, 1957; Bond, 1972) and estimates of flower drop run as high as 90% (Kambal, 1969).

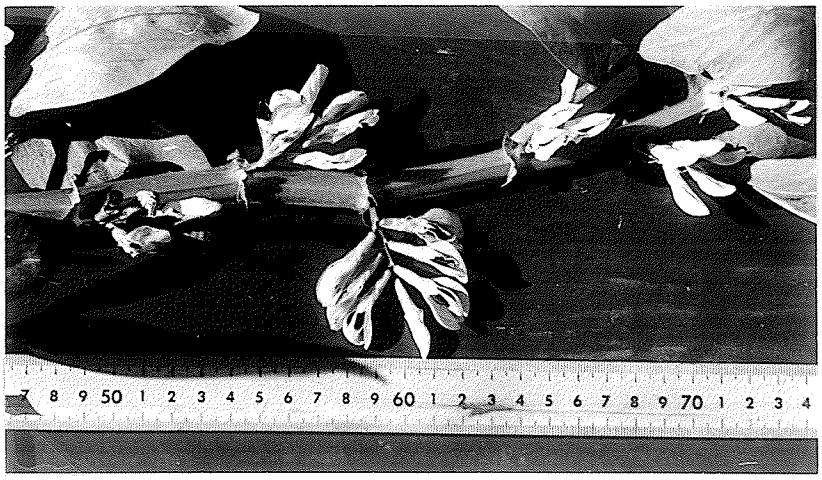


Plate 3.2.3. 6-8 flowers in cluster-formation, located directly on the stem.

L o d g i n g R e s i s t a n c e. Under Western Canadian conditions, stalk stiffness appeared to be adequate for most cultivars tested. Under extreme stress, however, the varieties Pavane and Strubes tended to show signs of lodging at Winnipeg, Brandon and Baldur in 1972. Of the trials conducted in the Maritimes, serious lodging was reported from Nappan, N.S. However, the data given would not indicate wether lodging was caused by breaking of the stems or uprooting due to soft ground. Under the more moist conditions of these regions, lodging resistance may be of greater importance.

R i p e n i n g. It proved to be rather difficult to obtain meaningful maturity data: the total lengths of time needed for all pods to mature is of little value for at least two reasons. First, with maturity progressing, shattering becomes a problem, especially under high temperatures. Second, there are indications that swathing may start early without yield loss, only the lowest 2 - 3 pods being mature. The data given in Table 3.2.1 should be regarded as tentative merely indicating variety relations. These dates were taken when one third to one half of the pods were black and their seeds hard. The plots were then regarded as being ready for cutting. As Table 3.2.1 indicates, the plots in 1972 were almost 10 days earlier on the average. One explanation for this could be the dryer growing conditions experienced in 1972.

F r o s t R e s i s t a n c e. Several cooperators reported frost at various stages of growth but very seldom and only minor damage to plants or yield losses could be connected with it (Table 3.2.2). There was one exception however. The trial at Lacombe/Alta. was reportedly destroyed by frost long before pods were ripe.

Table 3.2.2 Dates and degrees of frost recorded by cooperators and damage occured.

Location	Date of frost	Temp. ^{o}F	Damage
Truro, N.S.	June 12	30	Nil
Charlottetown, P.E.I.	Oct. 11	30	Nil
Melfort, Man.	Sept. 5	21	little or none
Beaverlodge, Alta.	Sept. 22	24	little or none
Edmonton, Alta.	Sept. 4	30	leaves turned black
Kamptville, Ont.	Oct. 1	?	heavy frost terminated growth
Brandon, Man.	Sept. 5	30	small if any

3.3 Inoculation, Fertilizer and Harvesting Experiments

I n o c u l a t i o n. In 1971, an experiment was conducted in the Carberry area to investigate the effect of various strains of *Rhizobia* on protein content. The trial was planted on land reportedly not having had peas or similar legumes for a long time. Nevertheless, nodules were found regularly on untreated plants. Although significant differences did not occur, the uninoculated entries were the lowest in protein content. Results are reported in Table 3.3.1.

Table 3.3.1 Effect of various strains of *Rhizobia* bacterias on protein content.

Treatment	Protein content %
Control	25.2
German Horsebean inoculum, pelleted	25.5
Nitragin Horseb. inoculum, pelleted	25.3
German Horseb. inoculum, powder	26.0
German Lupin inoculum, powder	26.7
German Sainfoin inoculum, powder	26.7
Nitragin Horseb. and pea inoculum	25.6
Nitragin azukibean inoculum	26.4
Control	24.1
Nitragin-Lupin inoculum	25.7
Nitragin-Sainfoin inoculum	25.3
Nitragin-Astragulus inoculum	25.7

L.S.D. P = 0.05 NS; SE ± 0.81

In 1972, the effect of inoculum was estimated in the yield trials, using 2 entries of Ackerperle: inoculated vs. uninoculated. The original results are reported in Table 3.1.1 to 3.1.4 and summarized in Table 3.3.2. On the average, the response to inoculum amounts to 2.7 qu/ha over the 21 locations.

Table 3.3.2 Effect of inoculum on seed yield of cultivar Ackerperle, summed over provinces.

Province	Seed yield (qu/ha)		
	Inoculum		Diff.
	-	+	
Manitoba *	27.2	31.3	4.1
Saskatchewan	31.9	34.8	2.9
Alberta	43.1	45.8	2.7
East and Maritimes	32.8	33.9	1.1
Mean	33.7	36.4	2.7

* exclusive Winnipeg and Glenlea

On an individual basis significant differences were obtained at Dauphin and Charlottetown with 14.3 and 8.4 qu/ha respectively in favor of the inoculum.

Effects of inoculum on quality properties were negligible. No significant differences were found in protein content, while 1000 kwt was slightly increased and bushel weight slightly decreased in control plots, (Tables 3.4.1 to 3.4.6).

These trials evaluated the effectiveness of a special inoculum on an overall basis. The mean response of 2.7 qu/ha hence would emphasize that inoculation is an economical proposition (see also Plate 3.3.1 and 3.3.2). However, several uncontrolled factors including soil fertility, bacterias present and amount of mineral nitrogen applied would greatly affect results (Lapinskas, 1969; McEwen, 1970a). Moreover, no attempt was made to clean out planting equipment in order to avoid contamination of control plots, a factor considered quite important since a clear trend was noticeable between replicates: first control plots planted usually gave lowest yields.

Plate 3.3.1. Control plot not inoculated, left; inoculated Ackerperle, right.

Plate 3.3.2. Many nodules after inoculation, left; few only in control plants, right.

F e r t i l i z e r E x p e r i m e n t. The results of this experiment are given in Table 3.3.3. It was aimed at evaluating harmful effects of mineral nitrogen when applied together with the seed.

Table 3.3.3 Effect of fertilizer placed with the seed on seed yield and protein of cultivar Ackerperle

T r e a t m e n t		Seed yield	Protein content
kg/ha		kg/ha	%
N	P_2O_5		
Control		35.1	26.8
11	48	37.9	28.4
16.5	72	37.9	29.0
22	96	37.8	28.0
27.5	120	36.3	28.7
33	144	35.9	30.6
L.S.D. P = 0.05		N.S.	-

As shown, treatment differences are not significant for seed yields. Evidently, under the present conditions seed yield is slightly decreased at levels above 22 kg/ha of nitrogen. A decrease in stand with increasing rate of application was noticeable and will probably account for the declining yields. These findings agree in general with those of McEwen (1970a), who found that rates of 112 to 336 kg/ha of nitrogen decreased germination, seedling stand and ultimately seed yields. It is concluded that the presently recommended fertilizer rate of 10 - 20 kg/ha of nitrogen is safe to apply with the seed.

Analysis of protein content shows an upward trend with increasing amounts of nitrogen, most effective at the initial rate of 11 kg/ha. In this context it must be noted that the experiment was planted without inoculum.

H a r v e s t i n g. The effect of cutting time at various stages of ripening on 1000 kwt and bushel weight is reported in Table 3.3.4. Only at a very early cutting stage, when the moisture content of the seed was 64 percent, did a reduction in seed weight occur. As for bushel weight, time of cutting had no effect.

The results obtained in the swathing experiments are given in Table 3.3.5. A slight decrease in 1000 kwt was noticed at a moisture content of 59 percent. At later stages of maturity, little differences in 1000 kwt were observed. The effects on bushel weight were similar to those of 1000 kwt.

Assuming that seed yield is governed at this stage by thousand seed weight, swathing could then begin early without appreciable yield losses. These results should be considered as tentative and more research is needed on this aspect. However, the data would also indicate that earliest swathing time should be considered when varieties are classified as to "days to mature".

With respect to swathing time, little information is available in the literature. It is however noted that desiccants should be applied only when most of the pods are ripe in order to avoid losses in yield and quality, (Willows, 1969; Anonymous, 1970b).

Table 3.3.4 Effect of cutting time on seed weight and bushel weight.

Classification of plants	Seed Moisture (%)	1000 Kwt (g)	B.W. (lbs)
Very green	63.9	363	68.0
Green	47.8	419	68.5
Near Ripe	37.4	417	67.5
Ripe	23.4	408	67.5

Table 3.3.5 Effect of swathing time on seed weight and bushel weight.

Date of cut	Seed Moisture (%)	1000 Kwt (g)	B.W. (lbs)
August 24	59.2	323	65.0
August 28	54.9	393	66.0
September 1	37.5	416	67.5
September 5	28.0	392	68.0
September 11	12.5	395	67.0

3.4 Quality Characters

C r u d e P r o t e i n C o n t e n t. Protein contents were determined for all yield trials in 1971 and 1972. Results are given in Tables 3.4.1 and 3.4.2 for Western and Eastern Canada, respectively. The overall mean protein content of 29% is close to that reported by Eden (1969) for fall planted fababeans grown in England. Eden reports a protein content of 32% for spring planted fababeans. Stählin (1957) gives an average value of 28.6 for fababeans grown in Germany. The conversion factors employed are not stated, however.

In the West, extremely low values were obtained at Indian Head in 1971, ranging from 23.3 to 26.9%; very high values were recorded at Lethbridge in 1972, ranging from 32.2 to 37.6%. With these exceptions, little variation existed between years and stations, as suggested by the low standard errors. On a varietal basis, 4 more or less distinct groups occurred.

Group 1 - Maris Bead with 32% protein.

Group 2 - the black-seeded cultivar Fioletowy with 31% protein.

Group 3 - the cultivars Diana and Pavane with approx. 30% protein content.

Group 4 - the cult. were Strubes, Ackerperle, Kleinkörnige and Erfordia with values of about 29%.

A negative correlation between protein content and seed yield becomes obvious. Maris Bead ranks first in protein content and last in seed yield; Erfordia ranks last in protein content and first in seed yield. This relationship is less pronounced in other cultivars (e.g.Pavane).

Table 3.4.1 Protein content (N x 6.25 on a dry matter basis) of fababeans tested in Western Canada in 1971 and 1972

Variety*	No. of locations	Protein %		
		Mean	+ SE	Range
Erfordia	20	28.7	± 0.3	25.5 - 32.2
Ackerperle,No In.	15	29.2	± 0.5	27.9 - 33.8
Ackerperle	20	29.2	± 0.4	26.0 - 34.6
Diana	20	30.2	± 0.4	25.7 - 34.0
Fioletowy	15	31.1	± 0.4	28.4 - 35.8
Kleinkörnige	20	29.1	± 0.4	23.3 - 33.6
Maris Bead	15	31.9	± 0.5	28.7 - 37.6
Pavane	20	30.2	± 0.4	25.6 - 34.6
Strubes	20	29.6	± 0.4	24.2 - 33.2
Glenlea Wheat	15	17.4	± 0.5	13.2 - 20.6
Ascott	4	29.0	± 1.1	24.5 - 31.7
Columba	4	29.0	± 0.8	25.5 - 30.6
Dornburger	4	29.2	± 0.7	26.9 - 31.0
Fribo	4	28.2	± 0.8	24.8 - 29.9
Herz Freya	4	28.1	± 0.9	24.9 - 30.1
Kl.Thüringer	4	28.7	± 0.6	26.8 - 30.4
Primus	4	28.3	± 1.0	24.8 - 31.1
Primeperle	4	28.0	± 0.8	24.9 - 29.9
Schladener	4	28.6	± 1.1	25.2 - 31.4
Mean (excl.Glenlea)	-	29.2	-	- -

* Ascott through Schladener tested in 1971 only

Table 3.4.2 Protein content (N x 6.25 on a dry matter basis) of faba-beans tested in Eastern Canada and the Maritime Provinces in 1972 at 7 locations

Variety	Protein %			
	Mean	±	SE	Range
Erfordia	29.3	±	1.0	26.7 - 34.8
Ackerperle, No In.	28.9	±	1.1	26.3 - 34.4
Ackerperle	28.9	±	0.9	25.7 - 33.2
Diana	29.9	±	1.1	26.8 - 35.6
Fioletowy	30.3	±	1.2	27.5 - 37.0
Kleinkörnige	29.4	±	1.1	26.8 - 35.4
Maris Bead	30.7	±	1.1	27.1 - 36.2
Pavane	30.0	±	0.9	27.8 - 35.2
Strubes	29.3	±	1.0	26.9 - 34.2
Glenlea Wheat	16.2	±	0.8	14.0 - 20.4
Mean (excl.Glenlea)	29.6		-	- -

As commonly experienced, protein values were lower in the East. This is the case but differences are slight (0.5 - 1%). The highest values were obtained at Kemptville/Ont., ranging from 33.2 to 37.0%, and lowest values at Charlottetown/N.S., ranging from 25.7 to 28.1%.

Results differed little at other locations, with a varietal pattern similar to that experienced in the West. No attempt is made to relate application of mineral nitrogen with protein content since information available on soil fertility is insufficient. But it is noteworthy that at both Kemptville and Lethbridge high levels of N were applied (App.I).

For Glenlea wheat, the average protein content obtained in the West was 17.4% as compared to 16.2% in the East.

B u s h e l W e i g h t. Results of bushel weight determination are given in Table 3.4.3 for Western Canada. The overall mean of 66.5 lbs is slightly above Glenlea wheat (63.5) and suggests sound kernels of high density. The varietal means are depressed by 2 locations, Edmonton and Beaverlodge. The bushel weights obtained at Edmonton ranged from 61 to 66, while the range at Beaverlodge was from 46 to 57. Without these, the bushel weight of Erfordia would change from 66.3 to 68.3; other varieties would be affected similarly. Beaverlodge was the only location were Glenlea wheat ranked first in bushel weight. Apart from this, variation between years and locations was marginal, as were the differences between varieties. Nevertheless, Kleinkörnige, Diana and Fioletowy rank first and Strubes last. Strubes has the largest seeds (Table 3.4.5) which explains its position.

Table 3.4.3 Bushel weight (lbs) of fababeans tested in Western Canada in 1971 and 1972

Variety*	No. of locations	Bushel weight (lbs) Mean	± SE	Range
Erfordia	19	66.3	± 1.2	46 - 70
Ackerperle, No In.	14	65.8	± 1.5	47 - 70
Ackerperle	19	66.8	± 1.3	45 - 70
Diana	19	67.3	± 1.1	48 - 70
Fioletowy	14	66.8	± 1.6	47 - 71
Kleinkörnige	19	67.6	± 1.2	48 - 71
Maris Bead	14	66.3	± 1.5	48 - 70
Pavane	19	66.5	± 1.2	46 - 70
Strubes	19	65.6	± 1.2	46 - 68
Glenlea Wheat	14	63.5	± 1.2	57 - 67
Ascott	5	69.0	± 0.9	65 - 71
Columba	5	69.4	± 0.8	66 - 71
Dornburger	5	68.0	± 1.1	63 - 70
Fribo	5	67.6	± 0.9	64 - 70
Herz Freya	5	69.0	± 0.9	65 - 71
Kl.Thüringer	5	68.6	± 0.8	65 - 70
Primus	5	69.0	± 0.7	66 - 70
Primeperle	5	68.6	± 0.8	65 - 70
Schladener	5	67.4	± 1.0	63 - 69
Mean**	-	66.5	-	-

* Ascott through Schladener tested in 1971 only

** Erfordia through Strubes only

Table 3.4.4 Bushel weight (lbs) of fababeans tested in Eastern Canada and the Maritime Provinces in 1972 at 8 locations

Variety	Bushel weight (lbs)			
	Mean	+	SE	Range
Erfordia	64.9	±	1.1	61 - 70
Ackerperle, No In.	63.6	±	1.7	52 - 69
Ackerperle	63.9	±	1.7	53 - 70
Diana	64.5	±	1.6	54 - 70
Fioletowy	63.8	±	1.9	51 - 70
Kleinkörnige	65.0	±	1.3	57 - 70
Maris Bead	62.4	±	2.6	44 - 69
Pavane	64.7	±	0.9	61 - 68
Strubes	63.5	±	1.3	56 - 68
Glenlea Wheat	56.7	±	4.2	30 - 64
Mean (excl. Glenlea)	64.0		-	-

In Table 3.4.4 results from Eastern Canada are reported, with an average weight of 64 lbs. or,2.5 lbs below the West. With one exception, variation between locations is small: at Kentville/N.S., weights recorded range from 44 to 57 lbs/bush.

Varietal differences are similar to these obtained in the West, but Maris Bead decreased appreciabely and ranks below Strubes, due largely to the results obtained at Kentville.

T h o u s a n d K e r n e l W e i g h t. Contrary to other characters, 1000 kwt is not in itself a quality criterion but it influences handling: small seeded varieties are less subject to breaks, which in turn will affect germination rate. Furthermore, costs of plantings will decrease with decreasing seed size.

Results of 1000 kwt are given in Tables 3.4.5 and 3.4.6. Small differences exist between Western and Eastern results, the weights being slightly higher in the latter. Varieties fluctuate more with respect to 1000 kwt than with protein content or bushel weight: 1972 results range from 50 to 100 g per thousand higher than those of the previous year. Very low values were recorded at Indian Head in 1971 ranging from 220 to 360 g per thousand.

Nevertheless, varieties tested for 2 years can be classified as follows:

A small seeded group with 1000 kwt ranging from 350 to 400 g: Ackerperle, Kleinkörnige, Fioletowy, Diana and Maris Bead.

A medium sized group with a 1000 kwt of 450 to 500 g: Erfordia, Pavane.

Table 3.4.5 Thousand seed weight of fababeans tested in Western Canada in 1971 and 1972

Variety*	No. of locations	1000 K w t (g)			
		Mean	±	SE	Range
Erfordia	19	442	±	13	324 - 542
Ackerperle, No In.	15	356	±	10	268 - 437
Ackerperle	19	344	±	11	264 - 409
Diana	19	402	±	14	248 - 488
Fioletowy	15	379	±	9	312 - 445
Kleinkörnige	19	361	±	10	232 - 426
Maris Bead	15	398	±	9	324 - 437
Pavane	19	475	±	13	300 - 544
Strubes	19	525	±	15	360 - 641
Glenlea Wheat	14	47	±	0.8	43 - 52
Ascott	4	371	±	38	265 - 479
Columba	4	312	±	26	234 - 365
Dornburger	4	396	±	35	288 - 471
Fribo	4	440	±	34	334 - 526
Herz Freya	4	358	±	25	278 - 419
Kl.Thüringer	4	424	±	31	342 - 515
Primus	4	336	±	19	280 - 374
Primeperle	4	288	±	26	220 - 368
Schladener	4	365	±	32	270 - 450

* Ascott through Schladener tested in 1971 only

Table 3.4.6 Thousand seed weight of fababeans tested in Eastern Canada and the Maritime Provinces in 1972 at 8 locations

Variety	1000 K w t (g)			
	Mean	±	SE	Range
Erfordia	470	±	18	386 - 542
Ackerperle, No In.	370	±	12	328 - 433
Ackerperle	366	±	10	334 - 405
Diana	427	±	16	364 - 483
Fioletowy	382	±	19	294 - 464
Kleinkörnige	391	±	12	320 - 433
Maris Bead	430	±	15	367 - 475
Pavane	516	±	20	442 - 635
Strubes	577	±	14	533 - 645
Glenlea Wheat	44	±	1.4	38 - 51

Cult. Strubes comprises the large-seeded group with 1000 kwt over 500 g, with a range up to 641 g.

Among the varieties tested in 1971 only, Primeperle is of interest having the very small seed size of 288 g per thousand, a fact which indicates that seed size is closely correlated to seed yield as Primeperle ranked last in the 1971 trials. The high yielding cultivars all belong to the group with a 1000 kwt of 450 g and over (Erfordia, Pavane and Strubes). A similar observation was made in other materials tested (Chapter 5).

4. SEED RATE AND SPACING TRIALS

4.1 Seed Rate

In 1971, a relative small range in seed yield with insignificant differences was obtained, although the rate applied ranged from 140 to 260 kg. This led to the addition of 2 more seed rate levels in 1972, increasing the range from 60 to 260 kg/ha. At the seed rate of 60 kg/ha, yields are depressed considerably, but rise rapidly by an almost constant amount of 5 qu/ha for each increment in seed rate, up to 38.3 qu/ha at a seed rate of 140 kg/ha,(Table 4.1). Little gain is made beyond this rate at the 15 cm spacing. At the wider spacing of 30 cm, the yield response is rather similar, the increase from 140 to 180 kg/ha being slightly more. Graphically, the response curves are almost identical and Figure 4.1 illustrates this point. While there is still an increase from 140 to 180 kg/ha, the curve flattens at this rate and becomes almost horizontal at the higher rates. From a practical point of view, planting costs at these levels would be prohibitive.

4.2 Spacing

The spacings used in both experiments were 15 and 30 cm and results are shown in Table 4.1. In both years, narrow spacing outyielded the wider spacing significantly, amounting to 19 and 5 qu/ha for 1971 and 1972, respectively.

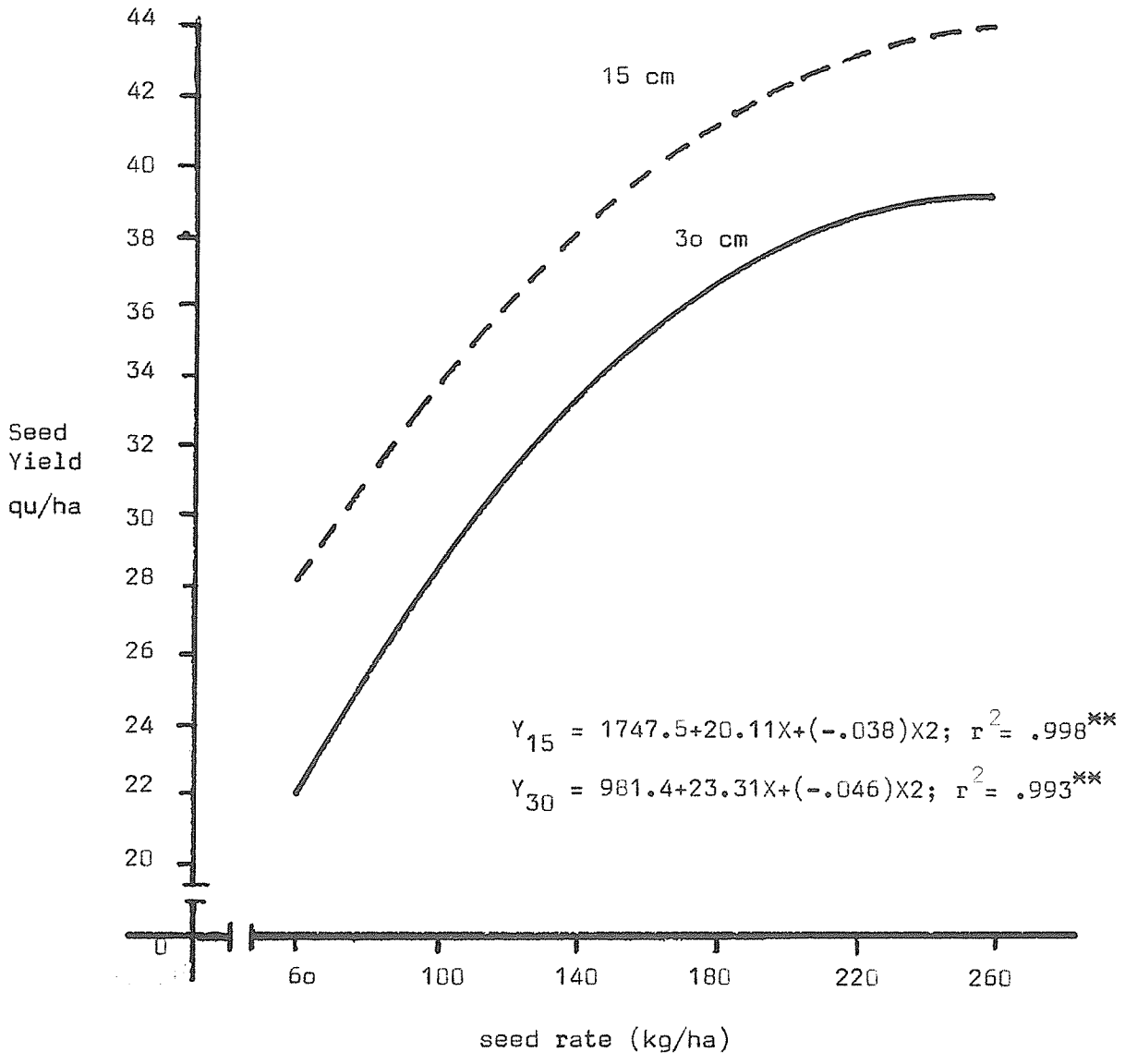
Table 4.1 Seed yield means (qu/ha) of seed rate and spacing trials at Winnipeg in 1971 and 1972

Seed rate (kg/ha)	Seed Yield (qu/ha)				
	1971		1972		Means
Spacing	15 cm	30 cm	15 cm	30 cm	(1972)
60	-	-	28.2	21.8	25.0
100	-	-	33.7	29.2	31.4
140	65.1	47.7	38.3	32.9	35.7
180	64.4	49.3	40.9	37.5	39.2
220	68.9	46.9	43.6	37.5	40.5
260	69.9	48.7	43.8	39.6	41.7
Means	67.1	48.2	38.1	33.1	35.6

S.E. of differences:

Spacing	1.6	0.4
Seed rate	2.4	1.1

Figure 4. 1. Regression of seed yield on seed rate on 2 row spacings, 15 cm and 3o cm, in 1972.



Seed rate and spacing interactions could not be detected in either year, (App. III).

P o d s p e r P l a n t. In both years components of yield were analysed to estimate compensation reaction of the fababean plant under various plant densities. The effects of plant densities on pod setting are given in Table 4.2. The overall effect of increasing density is a steady decline in the number of pods per plant. This decline was more pronounced in 1972, with growing conditions being less favorable. Pod set is generally higher at 15 than at 30 cm spacing, the respective means for 140 kg/ha seed rate being 16.1 and 13.5. Thus at a given seed rate, under the more crowded conditions of 30 cm spacing a relative decrease in pod set results, ultimately responsible for the depression of yields. Figure 4.2 demonstrates the relationships clearly for the 15 cm spacing. The decline in pod set is almost linear and identical for both years.

S e e d W e i g h t p e r P l a n t. The effects of seed weight per plant are presented in Table 4.2 and Figure 4.2. Seed weights also fall appreciably with increasing densities. This decline is very similar for both spacings in 1972. The better growing conditions of 1971 enabled the plant to compensate and the decline is less pronounced.

T h o u s a n d S e e d W e i g h t a n d B u s h e l W e i g h t. These characters are not influenced to any extent by densities or spacings, as is shown in Table 4.3. The differences found are insignificant.

Table 4.2 Number of pods/plant, seed weight/plant (g) (means of 90 and 60 plants in 1971, 1972, respectively) and seed weight/pod (seed weight per plant/number of pods) as affected by seed rate and spacing

Seed rate (kg/ha)	Pods/ Plant	Seed weight/ Plant (g)	Seed weight/ Pod (g)
		1971 - 15 cm spacing	
140	18.7 a	17.35 a	0.93
180	16.9 ab	16.60 a	0.98
220	14.9 bc	14.31 a	0.96
260	14.3 bc	14.87 a	1.04
		1971 - 30 cm spacing	
140	15.5 a	15.00 a	0.97
180	13.0 ab	12.71 a	0.98
220	12.0 b	12.09 a	1.00
260	11.4 b	11.30 a	0.99
		1972 - 15 cm spacing	
60	20.7 a	19.85 a	0.96
100	17.0 b	13.37 b	0.79
140	13.5 cd	11.17 bc	0.83
180	11.3 cde	11.43 bcd	1.01
220	10.3 cde	8.88 cd	0.86
260	8.2 e	7.67 d	0.93
		1972 - 30 cm spacing	
60	21.3 a	18.23 a	0.85
100	15.1 b	14.53 b	0.96
140	11.5 c	11.78 bc	1.02
180	11.4 cd	10.85 c	0.95
220	8.8 cd	7.28 d	0.83
260	7.1 d	6.87 d	0.97

Means followed by the same letter do not differ at the 0.05 level of probability

Figure 4. 2. Regression of seed rate on pods per plant at 15 cm row spacing, for 1971 and 1972.

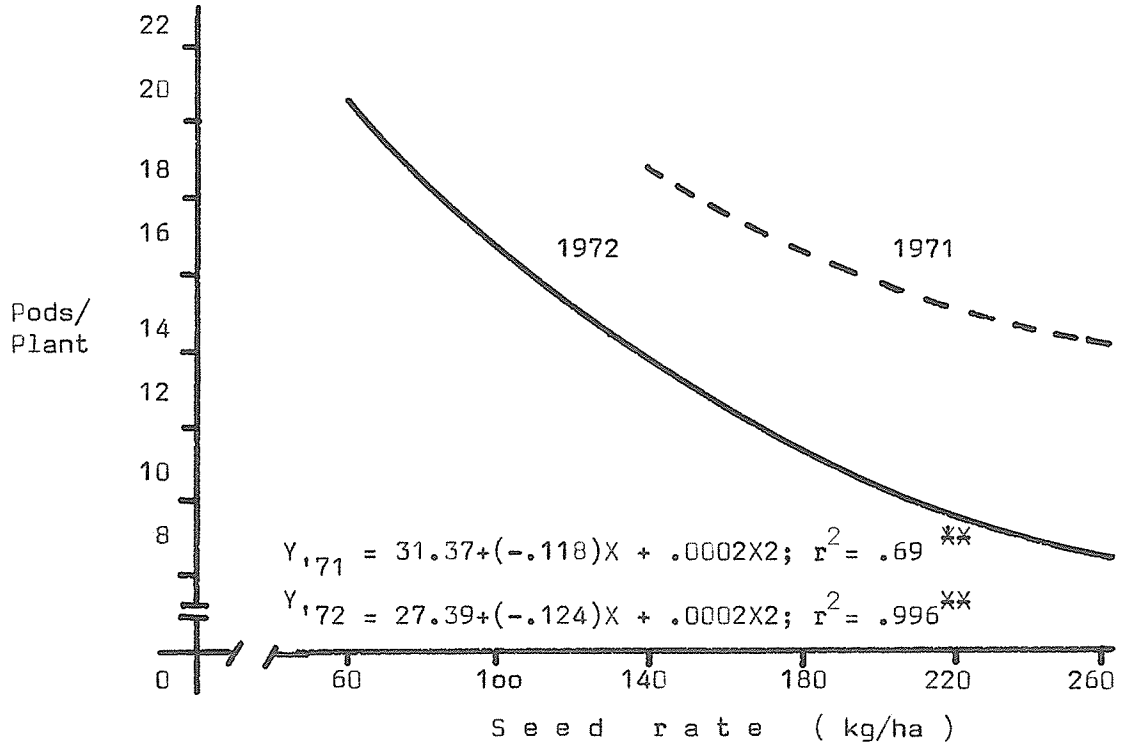


Figure 4. 3. Regression of seed rate on seed weight per plant for 1971 and 1972 at 15 cm row spacing.

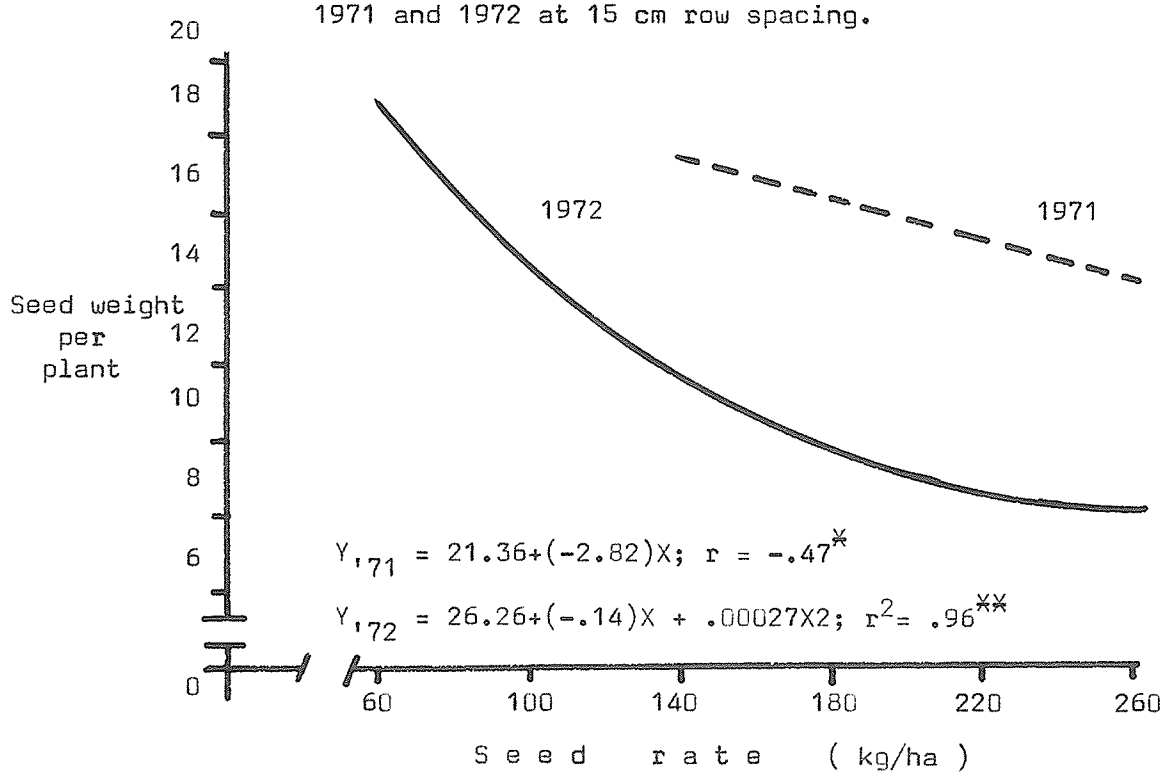


Table 4.3 Means of thousand seed weights (g) and bushel weights as affected by seed rates and spacing.

Seed rate kg/ha	Thousand seed weight (g)				Bushel weight (lbs)	
	1971		1972		1972	
Spacing	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm
60	-	-	390	376	69.0	69.8
100	-	-	390	372	68.9	69.2
140	303	310	388	374	69.1	69.6
180	315	300	390	380	69.0	69.4
220	300	329	389	374	69.2	69.2
260	311	318	390	385	69.8	69.3

Table 4.4 Protein content (% of total DM) as affected by seed rate and spacing.

Seed rate kg/ha	Protein percent			
	1971		1972	
Spacing	15 cm	30 cm	15 cm	30 cm
60	-	-	28.7	28.1
100	-	-	28.7	27.7
140	26.2	25.9	29.4	27.7
180	25.5	25.6	29.0	30.0
220	24.5	26.0	29.5	27.3
260	24.3	26.1	30.3	28.3

E f f e c t o f S e e d R a t e o n P r o t e i n. In Table 4.4 protein contents are given for the various densities. The 1971 results show little difference. In 1972 protein content increases parallel with seed rate at the narrow spacing but the differences are insignificant. No clear trend is noticeable at the 30 cm spacing. We can thus conclude that various densities have little if any effect on protein content, at least in the relevant range of seed rate (140 to 180 kg/ha). Clearly then, the usual dilution effect (rising yields = decreasing protein content) did not take place. This can be attributed to the efficient nitrogen-fixation of Rhizobia bacterias and their steady supply of N to the plant throughout the growing period (Candlish and Clark , personal communication).

C o n c l u s i o n s. The results show a definite advantage of narrow row spacing particularly under optimum growing conditions such as occurred in 1971. These results agree with Scandinavian data (Simon, 1970; Sjödin et al., 1972). Bardossy (1968) working under dry conditions in Hungary found that row spacing had very little effect.

A seed rate of 140 kg/ha which approximates 40 seeds per m^2 would probably be adequate for small seeded varieties such as Acker-perle but may have to be increased for larger seeded varieties.

The analysis of yield components revealed that the number of seeds per plant was increased under low plant densities but that seed weight per pod does not vary. This indicates that seed size and number of seeds per pod remain fairly constant. We can conclude that seed yield

is governed by the number of pods per unit area and that compensation for low plant density can take place by increased pod number but not by seed number per pod or seed weight per pod. This agrees with results obtained in England and Sudan by Hodgson and Blackman (1956) and Kambal (1969b), respectively.

5. SURVEY OF AGRONOMIC CHARACTERS OF NEW ACCESSIONS

Seed yield trials. In 1972, 36 collections from various places of Europe and Asia were tested at 3 locations; seed yields of these tests are given in Table 5.1. Erfordia was planted as a check and produced a satisfactory yield level of 30 and 33 qu/ha for Winnipeg and Teulon, respectively. The yield of Erfordia at Glenlea was only 15.7 qu/ha, due mainly to moisture stress in all stages of growth.

The varieties tested are grouped according to seed size. The range of yield obtained is considerable: from 21 to 46 qu/ha at Winnipeg, 14 to 40 qu/ha at Teulon and from 7 to 21 qu/ha at Glenlea. At Glenlea and Teulon few varieties exceeded Erfordia and the highest yielding varieties were medium or large seeded, but under the more favorable growing conditions of Winnipeg some small seeded lines approached the check yield. In Swedish experiments, Sjödin et al., (1972) also noted a negative correlation between seed size and seed yield.

Table 5.1 Survey of agronomic characters: Seed yield (qu/ha) tested at 3 locations in 1972

Variety/ Collection	Origin	Seed yield (qu/ha)		
		Winnipeg	Glenlea	Teulon
Small Seed Size, (up to 300 g per thousand)				
PI 221517	Afghan.	28.5	8.0	24.6
PI 221516	Afghan.	27.7	11.5	23.5
PI 222129	Afghan.	27.0	7.7	25.8
PI 222128	Afghan.	26.4	8.9	20.9
Medium Seed Size, (301 - 450 g per thousand)				
Kleinkörnige	Austria	40.5	11.1	27.4
Bell	GB	38.8	13.4	33.0
Niki	Netherl.	34.6	8.0	25.4
PI 254005	Afghan.	33.6	9.1	27.1
Wales 316/125	GB	32.8	15.0	32.7
PI 221517	Afghan.	32.5	11.9	23.6
PI 222129	Afghan.	31.8	13.0	25.3
Foecnevyje	USSR	31.5	11.2	33.3
Blue Rock	GB	31.1	12.4	30.8
Star Czyzowskich	Poland	30.7	9.5	26.9
Moroccan Feverole	Morroco	30.4	13.6	30.5
Elliot	USA	29.6	12.8	31.5
PI 223303	Afghan.	29.6	11.1	25.5
Ackerperle	Germany	29.2	8.1	29.2
Sultan	USA	29.0	10.0	25.4
PI 221517	Afghan.	27.9	8.6	22.0
Lielplatonskije	USSR	27.7	10.0	25.8
Wales 283/200	GB	27.2	11.4	27.5
Minor	Belgium	23.4	10.5	30.3
Pirhonen*	Finland	22.2	7.9	14.4
Large Seed Size, (451 g per thousand and over)				
Erfordia	Germany	30.0	15.7	33.0
Mestnyje	USSR	36.5	10.2	31.1
Rinal	Netherl.	34.6	11.5	36.2
Wales 355/95	GB	32.1	11.3	29.2
Nadwislanski	USSR	31.0	8.4	26.8
Krasnojerskije	USSR	28.3	10.5	31.1
Wales 882	GB	28.5	8.7	27.1
Burstinskije	USSR	27.0	11.8	27.1
Wales Tickbean	GB	26.6	10.8	26.5
Dagestanskije	USSR	21.3	8.4	21.2
Coeff. of variation		17.6	25.7	20.5
L.S.D. (0.05)		8.8	4.6	9.2
(0.01)		15.2	8.0	15.9

* badly shattered before harvest

The yield data indicate that the best varieties were of European origin, with Erfordia showing superior overall adaptibility. Other high yielding varieties were Bell, Wales 316/125, Foecnevyje, Blue Rock, Mestnyje and Rinal. These varieties also yielded well at Glenlea which was unexpected, since, under these dry conditions, collections of oriental origin were expected to outyield European varieties. Glenlea represents open, wind-swept growing conditions with heavy Red River clay and is quite representative of much of Southern Manitoba. The growing conditions in 1972 with precipitation of 0.93, 2.44 and 1.24 inches for May, June and July, respectively, give an indication of the performance of faba-beans under very dry conditions. All the oriental collections originating from dryland Afghanistan ranked below Erfordia at Glenlea. Selection to increase seed yields may however prove worthwhile in collections such as PI 221516, PI 221517, PI 222129 and PI 223303.

A combined analysis for the 3 locations showed no station x variety interactions.

P l a n t H e i g h t a n d L o d g i n g. All European varieties were rather tall and ranged from 110 to 117 cm at Winnipeg (Table 5.2). Stems of these plants were strong and the base diameters measured up to 15 mm. With maturity, the stems became woody and withstood heavy rain and wind without lodging. Nearby cereals lodged from 50 to 80%.

Plant height of the oriental accessions was considerably below the European varieties, the tallest ones measuring 70 cm. With the higher branching characteristic of these types, straw strength is reduced and lodging becomes a problem. Severe lodging was observed at

Table 5.2 Survey of agronomic characters: plant height (cm), height of first pod (cm), branching, lodging (1 = no lodging; 9 = complete lodging), days to maturity and pod form (s = smooth; c = constricted). Data taken from replicated tests in 1972

Variety/ Collection	Plant Height (cm)	Height of first pod(cm)	Branching*	Lodging		Day to mat.		Pod-form
				Winn.	Teul.	Winn.	Teul.	
Small Seed Size, (up to 300 g per thousand)								
PI 221517	70	10	m	1	3	106	114	c
PI 221516	65	16	vg	3	1	102	106	c
PI 222129	60	15	vg	3	7	100	106	c
PI 222128	65	15	m	3	4	106	112	c
Medium Seed Size, (301 - 450 g per thousand)								
Kleinkörnige	102	30	m	1	1	111	114	s
Bell	98	25	m	1	1	114	122	s
Niki	92	32	m	1	1	117	114	s
PI 254005	70	16	vg	3	1	104	106	s
Wales 316/125	100	30	l	1	1	112	122	s
PI 221517	65	15	m	3	9	106	114	s
PI 222129	67	18	g	4	9	104	106	c
Foecnevyje	100	18	m	2	1	110	114	s
Blue Rock	105	35	m	1	4	112	114	s
Star Czyzowskich	98	35	m	1	1	117	122	s
Moroccan Feverole	75	20	m	2	1	104	106	s
Elliot	92	27	m	1	1	110	118	s
PI 223303	70	14	l	1	1	106	106	c
Ackerperle	100	25	m	1	1	112	114	s
Sultan	103	30	l	1	1	110	114	s
PI 221517	75	20	g	3	1	107	106	c
Lielplatonskije	95	20	l	1	1	113	116	c
Wales 283/200	90	25	m	1	1	110	122	s
Minor	92	30	m	1	1	117	120	s
Pirhonen	60	5	vg	1	1	95	104	s
Large Seed Size, (451 g per thousand and over)								
Erfordia	95	30	l	1	1	114	114	s
Mestnyja	100	22	l	1	1	109	114	s
Rinal	94	30	m	1	3	115	122	s
Wales 355/95	100	27	m	1	1	112	122	s
Nadwislanski	94	32	l	1	1	117	128	s
Krasnojarskije	94	30	m	1	1	113	116	s
Wales 882	90	30	m	1	1	110	118	s
Burstinskije	102	30	m	1	1	117	116	s
Wales Tickbean	92	25	m	1	1	113	122	s
Dagestanskije	67	13	m	1	1	104	114	s

* l = low; m = medium; g = good; vg = very good

Teulon in entries PI 221517 and PI 222129, (Table 5.2).

L o w e s t P o d S e t. This characteristic is of special interest, since low pod set will ultimately result in harvesting losses. In the material tested, pod set ranged from soil level to 35 cm (Table 5.2). Erfordia and other European varieties set their pods from 25 cm upwards, which would permit swathing without losses; most of the oriental collections show rather low pod set.

B r a n c h i n g. The European varieties can be classified as exhibiting low to medium branching characteristics (Table 5.2).

The single rod row conditions of these experiments were conducive to branching, but few branches developed and these were late, yielding few if any pods (Plate 5.1). Compensation for thinner stands in these varieties therefore must take place in increased pod setting on the main stem.

Contrary to this, some oriental collections showed profuse branching such as PI 221516, PI 222129 and PI 254005 as well as the cultivar Pirhonen from Finland. It was noted that these varieties branch at the base of the plant, yielding several more or less equally advanced shoots. The main shoot is however still earlier and hence ripening is spread over a long period of time (Plate 5.2). This characteristic is a safety device and allows pod set over several weeks, which enables the plant to compensate for periods of adverse growing conditions.

With this mechanism, distribution of pods along the stem becomes thus an indicator of growing conditions: the more favorable season in

1971 yielded a pod set over the entire stem, while early drought in 1972 resulted in clusters of pods and consequently reduced yields (Plate 5.3 and 5.4).

One way to decrease costs of planting would be the use of branching varieties. However, low seed rates and thin stands result in little weed competition at early stages and a longer growing period. The limited data collected would suggest that the "Uniculm" type of variety (Donald, 1968), as represented by Erfordia and Ackerperle is probably the best adapted. Establishment of early yield components (branches) and the translocation of metabolites from side-branches to the main shoot during periods of stress, a theory advanced by McKey (1966) for a model plant for dry conditions, did not materialize in higher yields in the collections studied. Early growth coverage of the field and the utilization of stored moisture was important, since precipitation in May and early June was marginal. The fastest way to achieve coverage is increased seed rates. It is also conceivable that the short growing season of the Prairie does not allow for time-consuming compensation reactions such as development of lateral branches. Given the indeterminate habit of fababeans, European varieties seem to compensate for losses at one time by increased pod set at another, resulting in the observed cluster-formation.

M a t u r i t y was based on the time the crop would be swathed. At this stage, half to two thirds of the pods have turned color, appearing brown to black; the seeds of the lower pods are quite firm; lower leaves are dropped and the upper leaves show yellow discoloration but the stems are still green. Obviously, the whole plot

Plate 5.1

Branching in European varieties

Plate 5.2

Branching and ripening in oriental varieties

Plate 5.3 Pod set in 1971 over the entire stem

Plate 5.4 Pod set in clusters in 1972

Plate 5.5 Distant seeds mature before proximate seeds (right); Proximate seeds are aborted first (left)

still has a rather green appearance. For straight combining, the crop would need at least 10 to 14 more days, depending on weather conditions. Plate 5.4 depicts a plant ready to be cut. Maturation proceeds from the lower to the upper pods of the plant. Within a pod maturity starts at the distal seeds and moves to the proximal seeds, as can be seen in Plate 5.5 where color expression in the black-seeded variety is most advanced in the distant seeds. Plate 5.5 also shows that proximal seeds are aborted first in periods of stress (white seeded variety).

The earliest variety was Pirhonen, which matured in 95 and 104 days at Winnipeg and Teulon, respectively. (Single plant progenies of this variety revealed 2 distinct types, one ripening in 90 days). The range in maturity in the oriental collections was from 100 to 110 days at Winnipeg, while European varieties like Ackerperle and Erfordia were slightly later ranging from 112 to 114 days.

With the growing season in the Prairies being short, maturity is critical in the production of fababeans. Although it has been shown that the crop is quite tolerant to late frost, early frosts in September may terminate growth prematurely.

S h a t t e r i n g. Fababeans can be classified into 2 major groups according to their pod form, namely smooth and constricted pods (Table 5.2). Once ripe, the smooth pod is liable to shattering and varietal differences appear small. Since ripening starts at the lowest pods and differences between the most distant pods on a plant can be considerable, shattering can be a problem.

A combination of rain, heat and wind may enhance shattering. Rough estimates of shattering losses in experimental plots were 280 to 420 kg/ha.

The constricted pod, as found in some oriental collections showed good resistance to shattering (Plate 5.6 and 5.7). Bond (1968) also noted this characteristic in Mediterranean collections and proposed utilization of it in a breeding program.

S e e d C o l o r. The white seed coat is predominantly found in fababeans, but black-seeded ones were also among the oriental collections (Table 5.3). They are found among all 3 classes of seed size, but none of the black collections ranked in the top yielding group. Other than this, black-seeded collections did not seem to be correlated with the other characters studied. With respect to general seed appearance, black-seeded varieties have an advantage in that discoloration is less obvious (Plate 5.8).

S e e d W e i g h t. The 1000 seed weights are given in Table 5.3. The grouping into 3 classes is rather arbitrary and not in agreement with the classical division of *Vicia faba* into 3 subspecies (Plate 5.9), *V. faba minor*, *V. faba equina* and *V. faba major*, but should help to distinguish between important agronomic characters, without regard to broad beans (*V. faba major*).

S m a l l S e e d S i z e (up to 300 g/thousand). The first class with a seed weight of up to 300 g/thousand would be very attractive to producers as they would facilitate handling without major equipment adjustments. Unfortunately the yield potential of these small seeded types is below that of the other classes.

Plate 5.6 Constricted pods (top) vs. smooth pods

Plate 5.7 Extensive shattering experienced at Teulon

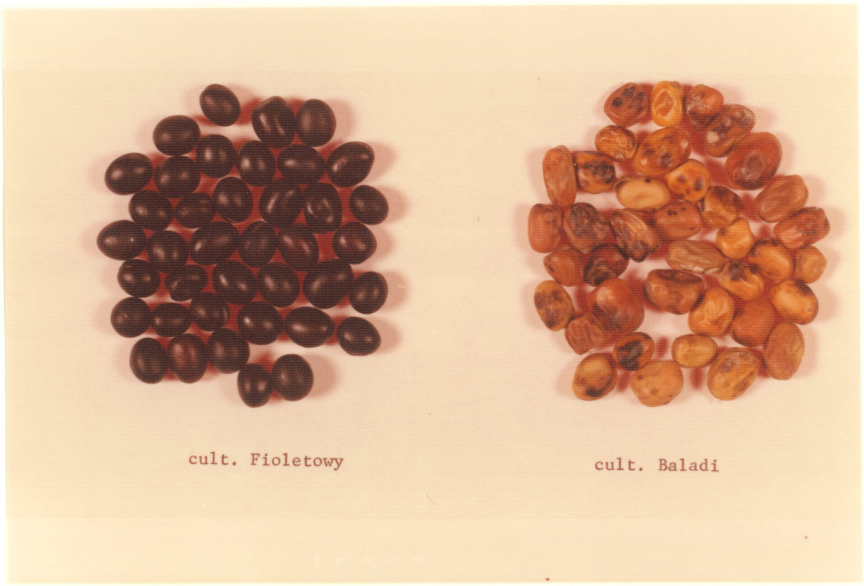


Plate 5.8 Black seeds look generally sound and shiny, left; discoloration is easily detected on a brown seed coat, right

Plate 5.9 Seed samples of the 3 subspecies of V. faba L.

Plate 5.10 Hail damage on a maturing pod at Winnipeg in 1972

M e d i u m S e e d S i z e (301 to 450 g/thousand). This class comprises several high yielding varieties, which performed reasonably well at all 3 locations (Bell, Foecnevyje). Handling difficulties increase with seed size, but only minor seeder and combine adjustments are necessary with this group.

L a r g e S e e d S i z e (451 g/thousand and over). None of the oriental collections fell into this class. With the exception of the Glenlea location, Rinal outyielded Erfordia. Other varieties in this group also yielded well. Obviously seed weight is an important yield component. Planting costs rise rapidly with seed size and considerable adjustments must be made to accommodate these large seeds during all stages of handling.

In general, seed weight proves to be a rather stable character, showing only minor variations under a range of environmental conditions. The data presented also indicate that large seed size is needed for high seed yields, since most of the top yielding varieties have seed weights above 400 g/thousand. This would agree with the findings of Donald (1968), who states that enough"sink capacity"is essential for high yields.

P r o t e i n C o n t e n t. The protein contents of the surveyed material is given in Table 5.3. The range of mean values is rather narrow (25.7 to 31.7%) with a concentration around 29%. There is little variation between locations, a situation similar to that for seed weight. Nevertheless, varieties such as Blue Rock, Sultan, Minor and Rinal show consistently high values.

Table 5.3 Survey of agronomic characters: seed color (w = white; b = black), 1000 seed weight (g), protein (% dry mass, N x 6.25). Data taken from replicated tests in 1972

Variety/ Collection	Seed color	1000 Seed Weight (g)			Protein %			
		Winnip.	Glenl.	Teul.	Winnip.	Glenl.	Teul.	Mean
Small Seed Size, (up to 300 g per thousand)								
PI 221517	w	300	294	282	28.3	25.5	29.8	27.8
PI 221516	b	296	298	254	28.6	25.9	30.0	28.2
PI 222129	w	242	244	232	20.7	25.5	30.8	25.7
PI 222128	w	305	296	287	28.7	24.6	31.0	28.1
Medium Seed Size, (301 - 450 g per thousand)								
Kleinkörnige	w	402	361	398	28.4	27.8	31.6	29.3
Bell	w	428	440	438	29.4	28.5	30.6	29.5
Niki	w	400	396	418	30.6	31.2	31.0	30.9
PI 254005	w	398	364	330	28.3	25.6	31.6	28.5
Wales 316/125	w	452	436	441	30.3	31.0	31.6	31.0
PI 221517	w	296	320	307	28.9	24.4	30.6	28.0
PI 222129	w	340	352	296	29.0	26.5	30.2	28.6
Foecnevyje	w	386	400	404	30.2	28.2	30.6	29.7
Blue Rock	w	386	358	396	31.4	30.0	33.6	31.7
Star Czyzowskich	b	394	371	398	29.3	28.2	31.0	29.5
Moroccan Feverole	b/w	330	438	450	29.0	27.7	31.4	29.4
Elliot	w	406	412	432	29.7	29.2	31.8	30.2
PI 223303	b	390	418	377	29.3	27.3	31.8	29.5
Ackerperle	w	384	348	387	29.6	29.0	30.6	29.7
Sultan	w	390	374	350	32.4	30.2	32.4	31.7
PI 221517	b	284	316	293	27.7	24.6	28.2	26.8
Lielplatonskije	w	386	398	411	28.8	28.2	30.4	29.1
Wales 283/200	w	444	438	446	29.0	28.4	31.2	29.5
Minor	w	356	346	350	31.9	29.8	33.0	31.6
Pirhonen	b	344	378	304	20.7	28.4	31.2	26.8
Large Seed Size, (451 g per thousand and over)								
Erfordia	w	448	504	508	29.0	28.1	30.6	29.2
Mestnyje	w	490	472	473	30.3	29.2	32.6	30.7
Rinal	w	656	560	592	31.1	30.2	32.8	31.4
Wales 355/95	w	484	420	490	30.9	29.6	31.2	30.6
Nadwislanski	w	482	438	449	29.0	27.8	28.2	28.3
Krasnojarskije	w	484	464	474	28.5	29.6	30.2	29.4
Wales 882	w	450	434	482	29.1	27.6	31.4	29.4
Burstinskije	w	470	486	508	28.5	29.4	31.0	29.6
Wales Tickbean	w	465	436	480	30.2	30.1	30.6	30.3
Dagestanskije	b	552	528	534	31.1	28.6	31.8	30.5

As to the consistency of protein content, the previously discussed efficiency of nitrogen-fixing bacterias, living in symbiosis with the plant, might offer an explanation for this phenomenon.

6. PESTS AND DISEASES

Leaf and Pod Spot Disease, Ascochyta fabae. In 1971, this disease was noted and identified on 2 varieties, Baladi and Bf 12/2, both originating from the Sudan. The infestation occurred towards the end of the season and was confined to these varieties (Plate 6.1 to 6.3). As a precaution, both varieties were excluded from the 1972 variety trials. In 1972 Baladi was planted under isolation to check the effectiveness of seed treatment for the control of A. fabae. Results of this experiment are given in Table 6.1. As in the previous year, infection started late and little damage occurred. Although yield differences were not significant the degree of control by Captan was very evident.

Table 6.1 Effect of seed treatment on incidence of A. fabae: seed yield means (g/plot), infected pods and leaves (percent).

Treatment	Seed yield (g)	Infection %	
		leaves	pods
1 Undiseased seed, untreated	358	trace	trace
2 Undiseased seed treated with Captan	341	trace	trace
3 Diseased seed, untreated	294	10-25	30-35
4 Diseased seed, treated with Captan	329	trace	trace
C.V.	21.0		
L.S.D. (0.05)	N.S.		

In Europe, A. fabae is regarded as being a very destructive disease (Griffiths, 1969). Outbreaks of A. fabae in North America were also reported by Hough (1972) on field scale experiments in Nova Scotia. A. pisi, a common disease on peas can also attack fababeans (Beaumont, 1950).

Control of A. fabae in Europe is exercised by sanitation and by the use of sound seed (Griffiths, 1969); Mercury seed treatment was found ineffective (Hewett, 1966; Derenne, 1967; Griffiths, 1969). Reports on other fungicides as seed treatments for the control of A. fabae are not available.

Plates 6.1 and 6.2

A.fabae on pods and leafs of cult. Baladi

Plate 6.3 The entire plant attacked by A. fabae.

Plate 6.4 Seeds infested with A. fabae

B e a n R u s t (Uromyces fabae). Bean rust was noted and identified on several oriental collections (Plate 6.5). The outbreak occurred late in the season and little damage occurred. Bond (1969) reports that U. fabae usually develops late in the year and is consequently of little importance.

A l t e r n a r i a. This disease was also found and identified on several samples, especially on the lower leaves (Plate 6.6), but little damage could be ascribed to it.

V i r u s D i s e a s e s. In 1971, several plants showing symptoms of virus infection were noticed, but none appeared in 1972. Plate 6.7 shows a plant with marbled leaves, typical of both pea enation mosaic and pea mosaic virus. Conclusive identification was not possible. Both diseases are reported by Heathcote and Gibbs (1962) as being of minor importance.

Plate 6.8 shows a plant with cupped and stunted growth and interveinal chlorosis, symptoms ascribed to Bean Leaf Roll Virus (BLRV), conclusive identification was again not possible. BLRV is reported as being the most destructive virus on beans (Heathcote and Gibbs, 1962).

C a r a g a n a B l i s t e r B e e t l e. In 1971, localized defoliation, caused by a blister beetle was noted. In 1972, a heavy infestation occurred on the plots at Winnipeg. The beetle was identified as the caragana blister beetle, Epicanta subglabra (Fall). It was found that foliar sprays with Malathion were not effective, but the chemical Guthion gave immediate control.

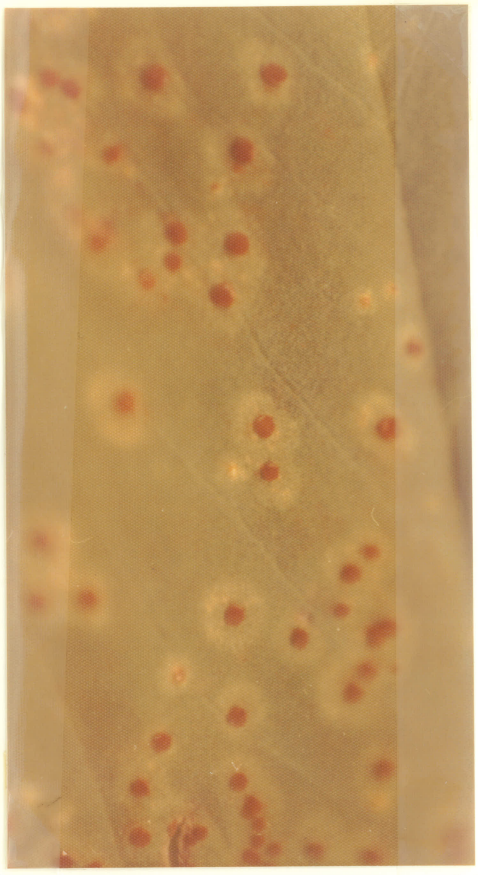


Plate 6.5 Bean rust on leafs (Uromyce fabae)

Plate 6.6 Alternaria on lower leafs

Plate 6.7 Pea (enation) mosaic virus on fababeans

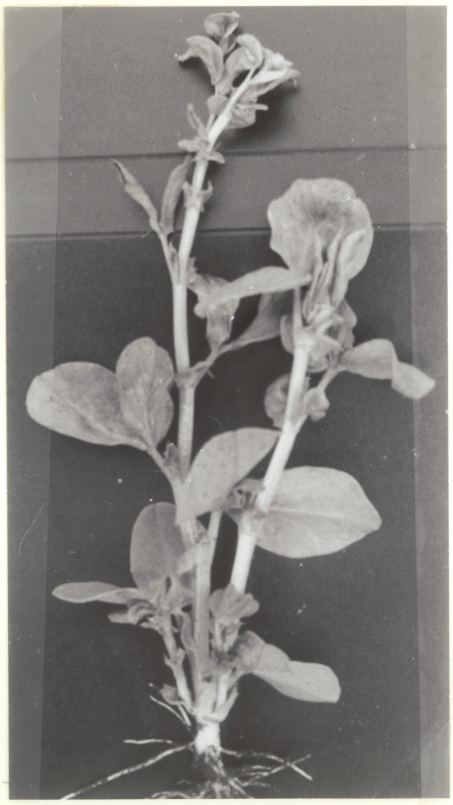


Plate 6.8 Bean leafroll virus

B e e t W e b w o r m. Several larvae defoliating the crop at a fast rate were identified as belonging to the beet webworm, Loxostege sticticalis L. The damage done was confined to a few plants.

T h r i p s. In 1971, nearly every flower was inhabited by thrips, sometimes numbering 20 or more. The thrips were identified as Frankliniella tritici (Fitch), one of the most common thrips in North America associated with many plants (Richards, personal communication). The insects feed on pollen grain and by sucking on flower parts.

Besides the apparent pollinating effect, little or no damage could be ascribed to them. The plots at Winnipeg were sprayed twice with Malathion, but application was ineffective. Very few thrips were observed in 1972.

C o n c l u s i o n. It was found that the leaf and pod spot disease of fababeans, Ascochyta fabae, can be very destructive and constitutes a risk of great potential. The occurrence of A. fabae was confined to few experimental plots at the Winnipeg test site with none of the other locations in Western Canada reporting its occurrence. Obviously, with increasing acreage this seed borne disease could spread quickly especially if the seed supply is not controlled.

As indicated by several cooperators in the East, A. fabae is already established and crops may be at greater risk there under the prevalent high air humidity condusive for spreading and infection.

Since symptoms of A. fabae are similar to those caused by chocolate spot, Botrytis fabae, identification is sometimes a problem and reports obtained from locations in the Maritimes as to the occurrence of "blight", "leaf spots" etc. may be caused by either B. fabae and/or A. fabae. However the level of infection in the yield trials was in general very low and without visible effect on seed yields. B. fabae can be controlled by sanitation (deep ploughing of crop residues, long rotation cycles, clean seed).

The major pest reported to endanger fababean production is the black aphid, Aphis fabae Scop. This may be a lesser problem in the West since none of the reports obtained from Western cooperators indicated aphid problems. Of the trials conducted in the Maritimes, aphids were a serious problem at Charlottetown and Nappan and lighter infestation occurred at Kentville and Fredericktown. Effective control was obtained with Malathion and Disulfton.

The caragana blister beetle, Epicanta suboglabra, was found to be quite destructive in some Manitoba trials but was not reported elsewhere. This pest is easily controlled but air-application may be necessary in order to avoid wheel damage.

The trial at Kemptville was attacked by potato bugs.

7. C O N C L U S I O N

In the two year testing period, of the 31 yield trials planted 29 were harvested and yielded an average of 35 qu/ha. This average includes all varieties. The average highest yield of fababeans (max. yield at each location) was 40.6 qu/ha. The potential of the crop was further indicated at Winnipeg in 1971 with yields above 60 qu/ha and of 55 qu/ha at Beaverlodge/Alta. in 1972. The wheat check yielded 37.3 qu/ha on the average.

Undoubtedly, fababeans are best adapted to areas of adequate water supply and although 6 inches of precipitation during the growing period may be enough if well distributed, early drought periods seem to be more harmful to fababeans as compared to wheat. The near failures observed at Glenlea and Morris in 1972 on heavy clay soils may be attributable to drought or a combination of drought on the particular soil type.

It seems likely that a slight increase in seed rate from presently 150 kg/ha to 180 kg/ha might be advantageous in stabilizing yields.

The study also showed that fababeans could be an important source of vegetable protein. Assuming similar yields of wheat and fababeans, protein production of fababeans amounted to (30 qu/ha x 29%) 8.7 qu/ha as compared to (30 qu/ha x 17%) 5.1 qu/ha for the wheat check, e.i. a 70 percent increase over wheat.

With respect to the amino acid composition of fababeans, the high portion of the lysine component is of special interest; fababeans have a lysine content of 6.84 percent of the total protein fraction as compared to 2.58 percent in wheat. However, fababeans contain only half the methionine content of wheat (App.IV).

In conclusion, the data presented would indicate that-

(1) the varieties presently available to farmers are reasonably well adapted and express a high yield potential;

(2) the forthcoming varieties of European and Oriental origin may bring about improvements in certain agronomic characteristics e.g. shattering resistance, but will unlikely increase the seed yield level;

(3) fababeans produce yields similar to wheat on the average but will better utilize optimum growing conditions;

(4) fababeans produce a crop with 29 percent protein content with little fluctuation over a wide range of environments;

(5) the amino acid composition of fababeans is typical for legumes, e.i. high in lysine, arginine and aspartic acid and low in methionine and other sulphur containing amino acids, relative to wheat.

This study has shown that fababeans can be grown successfully in the Prairies and elsewhere in Canada, a fact partly verified by the many growers in 1972. In view of the ever increasing and world wide shortage of vegetable protein, here is a crop of great potential in producing high yields of protein of favorable amino acid composition - a crop so far largely neglected in many parts of the world.

Appendix I

Dates of seeding and cutting, precipitation, soil type and fertilizer application

Cooperator/ Location	Year	Date of seeding	Date of cutting	Precipitation April-July (inch)	Soil-type	Fertilizer N - P - K (kg/ha)
Manitoba						
U.of M. Winnipeg	1971	May 5-	Aug. 30	10.95	m	Nil
	1972	May 2-	Aug. 16	5.52	m	Nil
U.of M. Glenlea	1972	May 3-	Aug. 18	5.25	c	Nil
U.of M. Baldur	1971	May 11-	Sept.10	13.91	m	Nil
	1972	May 15-	Sept. 9	11.78	m	10-45- 0
U.of M. Teulon	1972	May 11-	Sept. 4	6.01	m	10-45- 0
U.of M. Morris	1972	May 5-	Sept. 1	6.53	c	10-45- 0
U.of M. Dauphin	1971	May 15-	Sept.24	10.99	h	27-34- 0
	1972	May 20-	Sept.12	6.49	m	10-45- 0
CDA, Brandon	1972	May 25-	Sept. 8	6.99	m	Nil
CDA, Morden	1972	May 9-	Aug. 30	6.91	m	Nil
Saskatchewan						
CDA, Indian Head	1971	May 26-	Sept.22	9.08	c	7-31- 0
	1972	May 15-	Sept.14	7.81	c	7-31- 0
CDA, Swift Current	1971	May 10-	Aug. 24	7.18	m	Nil
	1972	Apr.27-	Aug. 24	5.84	m	Nil
CDA, Melfort	1971	May 5-	Sept.15	9.13	m	Nil
	1972	May 10-	Sept. 9	5.37	m	Nil
CDA, Saskatoon	1972	May 5-	Sept. 5	irrig.	m	7-27- 0
Alberta						
U.of A. Edmonton	1972	May 1-	Oct. 1	10.01	m	11-56- 0
CDA, Lethbridge	1972	May 12-	Sept.12	7.10	m	36-45- 0
CDA, Beaverlodge	1972	May 9-	Oct. 4	4.56	h	Nil
East and Maritimes						
Agr.Coll.Kemptville,Ont.	1972	May 15-	Oct. 12	17.50	l	112-12-112
CDA, Ottawa	1972	May 15-	Aug. 22	16.81	h	6-22- 11
U.of Laval, Quebec	1972	May 8-	Sept.11-28	13.12	l	9-18- 18
NSAC, Truro	1972	May 15-	Oct. 3	(13.33)	l	21-87- 87
CDA,Charlottetown,PEI	1972	May 27-	Sept.25	13.75	m	56-99-186
CDA,Kentville, NS	1972	May 26-	Sept. 1	13.81	m	0-56- 56
CDA,Fredericktown, NB	1972	May 26-	Sept.15	13.23	m	11-22- 11
CDA,Nappan, NS	1972	May 25-	Oct. 11	16.60	m	6-22- 22

m = medium; h = heavy; c = clay; l = light soil

Appendix II

Combined analysis of variance of fababeans tested on 6 locations in 1971

Source	DF	MS	F
Replications	12	342142.6	7.4**
Stations	5	16520998.0	356.6**
Varieties	14	281187.0	6.1**
Stations x Varieties	70	94490.1	2.04**
Error	168	46329.8	

** indicates significance at the P = 0.01 level

Combined analysis of variance of fababeans tested on 29 locations in 1971 and 1972

Source	DF	MS	F
Replications	46	188384.7	6.99**
Stations	22	2401578.0	89.1 **
Varieties	9	351351.3	13.0 **
Stations x Varieties	198	101421.4	3.76**
Error	414	26944.8	

** indicates significance at the P = 0.01 level

Appendix III

Analysis of variance - seed rate trials

Source	DF	MS	F
1 9 7 1			
Replications	5	8051.2	
Mainplots (spacings)	1	966144.0	130.87**
Main Plot Error	5	7382.4	
Subplots (seed rates)	3	4448.0	0.579 NS
Spacings x seed rates	3	7290.7	0.949 NS
Sub Plot Error	30	7684.8	
Total	47		
1 9 7 2			
Replications	5	36556.8	
Mainplots (spacings)	1	1377280.0	124.54**
Main Plot Error	5	11059.2	
Subplots (seed rates)	5	1482444.0	68.38**
Spacings x seed rates	5	12646.4	0.58 NS
Sub Plot Error	50	21678.1	
Total	71		

**,indicates significance at the P = 0.01 level

NS,non significant

Appendix IV

HORSEBEANS — A PROTEIN CROP FOR WESTERN CANADA?

Several cultivars of horsebeans and tickbeans (two small-seeded subspecies of *Vicia faba* L.) have been tested in Manitoba and Saskatchewan in 1970 and 1971.

Although significant yield differences have been obtained (Table 1), the limited yield comparisons with cereal crops are of great interest. In the two trials that included the high-yielding wheat cultivar Glenlea, the wheat yield was significantly below that of the better bean cultivars and was below the test mean yield in both trials.

Agronomically, horsebeans appear well adapted to the moister portions of the cereal-growing area. Early deep sowing into a well-drained firm seedbed gave the best results. Inoculation with pea inoculum may be beneficial but preliminary observations must be confirmed by additional results.

The smaller-seeded cultivars can be handled with standard cereal machinery. The beans are frost-tolerant in spring and grow rapidly even under cool conditions. They grow to approximately 1 m in height and have excellent straw strength permitting straight combining. Disease and weed problems have not been a factor in early tests, but obviously must receive attention.

Protein contents (N × 6.25 dry basis) ranged from 23 to 32% (Table 2) with only minor location or year variation, except for the relatively low overall protein content recorded at Indian Head.

Table 1. Seed yield of horsebeans in kg/ha

Cultivar	Winnipeg 1970	Winnipeg 1971	Baldur 1971	Dauphin 1971	Swift Current† 1971	Melfort 1971	Indian Head 1971	Mean
Ascott	2790	5511	3900	2270	2149	2782	1733	3019
Columba	3060	5000	3118	2200	1923	2069	1793	2737
Diana‡	2647	4764	3763	3010	2432	2177	2247	3006
Dornburger	3237	5746	3474	2550	2298	2173	1620	3014
Erfordia	3183	6615	3644	3000	2877	2923	2178	3488
Fribo	3490	5831	3689	2410	2500	3134	1847	3271
Herz Freya	2687	5593	3863	3090	2586	2952	1876	3249
Wies. Kleinkröniger‡	3637	7015	3756	2350	2103	2504	1435	3257
Pavane	2493	6249	4407	2720	2532	2621	2122	3306
Kl. Thüringer	3007	5460	3230	2890	2660	2497	1973	3102
Primus‡	–	4862	4030	2620	2280	2311	1247	2892
Primeperle‡	2560	4371	3496	1990	1863	2322	1131	2533
Schladener	3277	4838	4252	2860	2320	2842	2049	3205
Strubes	2740	4691	4518	3280	2666	2933	2111	3277
Ackerperle‡	–	6089	3778	1990	2189	2201	1527	2962
Glenlea (feed wheat)	–	3831	–	2330	–	–	–	(3080)
Mean	2985	5404	3801	2598	2358	2563	1793	3069
SE	88	488	259	244	153	183	176	
LSD $P=0.05$	255	1389	750	709	444	530	510	

†Irrigated once in August (2 inches).
‡Usually referred to as tickbeans, due to smaller seed size.

Table 2. Protein analysis of horsebeans in percent (N × 6.25 dry basis)

Cultivar	Winnipeg 1970	Winnipeg 1971	Baldur 1971	Dauphin 1971	Indian Head 1971	Melfort 1971
Ascott	29.1	30.9	31.7	29.0	24.5	29.0
Columba	29.1	30.1	30.6	30.1	25.5	28.8
Diana	29.2	29.6	32.1	31.3	25.7	28.2
Dornburger	24.8	28.8	31.0	31.0	26.9	28.4
Erfordia	28.8	29.2	30.1	30.3	25.5	26.9
Fribo	27.6	28.6	29.6	29.9	24.8	28.4
Herz Freya	28.3	28.6	30.1	29.9	24.9	27.1
Wies. Kleinkörnige	27.0	28.1	30.3	29.9	23.3	27.0
Pavane	31.9	28.7	30.7	31.8	25.6	28.1
Kl. Thüringer	30.5	29.3	30.4	29.9	26.8	27.3
Primus	–	27.4	31.1	30.1	24.8	28.5
Primeperle	28.6	28.9	29.2	29.9	24.9	27.1
Schladener	29.1	29.4	31.4	30.9	26.3	25.2
Strubes	29.7	29.6	31.2	29.8	24.2	26.2
Ackerperle	–	28.1	30.5	29.4	26.0	26.9
Glenlea	–	18.2	–	15.5	–	–

Amino acid analyses (Beckman 121 Amino Acid Analyzer, 18 hr hydrolysate) showed that horsebeans contain considerably more lysine than wheat (Table 3). The amino acid values for Manitou are typical of wheats that vary little with cultivar or type. The low methionine content in horsebeans is typical of most legumes, whereas lysine is usually the limiting amino acid in the nutritional value of cereal grains. Accordingly, the addition of horsebeans to wheat should improve the nutritional value of wheat in proportion to the additional lysine.

Further analyses were made on a sample of one cultivar of horsebeans (cult Prime Perle). Two dehulling tests on the same sample showed that most of the fiber could be removed by dehulling and that the hull protein content averaged 16.6% (Table 4). Dehulled horsebeans could prove to be a useful source of protein for animal and human nutrition.

Table 3. Amino acid in percent of total protein

Amino acid	Horsebean (cult Columba)	Hard red spring wheat (cult Manitou)
Lysine	6.84	2.58
Histidine	2.78	2.39
Arginine	10.26	4.36
Aspartic acid	11.90	5.10
Threonine	3.85	2.94
Serine	5.30	4.91
Glutamic acid	18.30	36.40
Proline	4.61	12.09
Glycine	4.75	4.34
Alanine	4.56	3.64
Valine	4.78	4.43
Methionine	0.86	1.61
Isoleucine	4.25	3.83
Leucine	7.96	7.58
Tyrosine	3.31	2.54
Phenylalanine	4.53	5.55

Table 4. Analyses of Primeperle horsebeans

	Whole bean	Dehulled bean	Hulls
Proportion of total bean (%, dry basis)	100	83.4	16.6
Dry matter (%)	87	87.0	89.4
Protein content (N × 6.25, dry basis)	28.5	32.6	6.0
Crude fat (%, dry basis)	1.1	1.1	0.2
Crude fiber (%, dry basis)	8.5	1.1	44.1
Energy (kcal/g)	3950	3992	3872

Detailed nutritional and technological studies are in progress. Field scale agronomic tests are planned for 1972.

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