THE PEA CROP

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The Pea Crop

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The Pea Crop

A Basis for Improvement

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PREFACE

When Mendel crossed the garden pea
It segregated one to three.
A friend then said 'If that is true
It ought to work with this plant too'.
So Mendel, sitting in the sun
Tried crossing the Hieraceum.
How sad that he was thereby tricked
By a compulsive apomict.

'It does not segregate', said he
'This gift from Karl von Nägeli
And so I'll die and wait in peace
For Correns, Tschermak and de Vries'.
'Too good a fit' then Fisher cried,
'I think these figures falsified!
What need had he of such deception
When guided by divine perception?'

After-dinner doggerel verse in honour of the centenary of Mendel's death,
W.J. Whittington (1984)

Choosing The Pea Crop as the subject of the University of Nottingham 40th Easter School in Agricultural Science, held at the School of Agriculture, Sutton Bonington from 2 to 6 April 1984 was particularly timely. Interest in dried peas as an alternative source of vegetable protein to imported soya rapidly escalated following the introduction in 1978 of an EEC subsidy on peas and beans for animal consumption. At the same time, an increasing awareness of the beneficial role of peas as an arable break crop was developing both within Europe and in other parts of the world. Furthermore, against a background of increasing physiological and agronomic understanding, plant breeders had started to pay increasing attention to the difficult task of remodelling grain legumes into more desirable crop plants. However, focusing attention on peas soon highlighted the immediate need for improving various aspects associated with the crop, for example its poor standing ability, low yields and yield instability and soil-borne disease problems.

The aim of the conference was to formulate a basis for improving the pea crop by bringing together international scientists to present current research findings and review published work on a wide range of subject areas encompassing pea genetics, plant breeding, agronomy, crop and plant physiology, utilization and marketing. While most papers concentrated on the dried (combining, field) pea crop, coverage extended to vining (garden) and forage peas with occasional reference to other grain legumes. Approximately 130 delegates from universities, commerce, industry and practical agriculture, representing 15 countries, contributed to one of the largest-ever international gatherings of individuals interested in furthering the development of the pea crop.

Although more problems than solutions were discussed, an atmosphere of optimism and confidence prevailed. It was generally agreed that there was immense scope for future improvements and that the bonds of friendship and co-operation either formed or strengthened during the meeting could only facilitate progress in this direction. We extend our thanks to all delegates for participating in such a friendly and whole-hearted manner.

We would like to express our sincere gratitude to all of the following who helped to ensure that the conference was a success: Mrs Mavis Secker, the Conference Secretary, for devoting considerable time, energy and enthusiasm towards the smooth running of the conference and Mrs Jeanne Rodwell for secretarial assistance; Dr Cliff Hedley, Mr Brian Snoad, Dr Peter Matthews, Professor H.W. Woolhouse and other members of the John Innes Institute for advice and assistance in planning the conference programme; Professor J.D. Ivins and Professor W.J. Whittington for their support, encouragement and helpful advice throughout the conference organization; Messrs Barry Hunter and David Hodson and Mrs Sonia Manison for assisting with visual aids; and Miss Cathy Chatham, Miss Christine Jones, Miss Sarah Barrett and Mr Alan Almond for assistance during the meeting.

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OPENING ADDRESS

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THE PEA CROP—AGRICULTURAL PROGRESS, PAST, PRESENT AND FUTURE

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Introduction

The dried pea has been a good source of nutritious food since Neolithic times. *Pisum sativum* L. (*partim*) is the type most widely used for human consumption and interest in its use as an animal feed has increased in recent years in developed countries. The species includes varieties used for soaking and cooking at home, canning as 'processed' peas, for canning and quick-freezing as 'mushy' peas and for harvesting fresh at home and in particular for quick-freezing, canning and dehydrating in the immature stage as 'garden' or vining peas.

The type *P. sativum arvense* L. (field pea) is used for animal feed, while *P. sativum axiphium* L. (sugar pea) is used for eating both pod and seed as a green vegetable.

Consumption of green peas was restricted to the appropriate season until the introduction of canning. This process, and the arrival of the mechanical sheller or 'viner' at the Paris Exhibition of 1885, led to the gradual development of the canning industry. The successful reconstitution of dried peas as 'processed' peas was achieved in the UK in the 1930s; quick-freezing soon followed but developed slowly.

Peas can be used as forage for cattle and yields are similar to one cut of grass with much lower fertilizer costs. Feeding value is a little lower than grass, despite higher crude protein content. Forage peas are of considerable importance in eastern Europe, and may well increase in importance elsewhere (Anslow, Burgis and Sheldrick, 1983).

Peas are grown world-wide (*Tables 1.1* and *1.2*) but, because of sensitivity to extremes of climate, are largely confined to temperate regions, and the higher altitudes or cooler seasons of warmer regions.

Pea production in Australia and Israel is restricted because of environmental factors such as drought and high temperature, and in the Transvaal area of South Africa because of frost during the flowering period. The former environmental problems are overcome in India by restricting production to higher altitudes.

Peas are a crop best suited to well-drained soils of good texture and are especially sensitive to stress during establishment and flowering.

Yields vary greatly between countries, with the highest yields being produced in the UK for vining peas and in France for combining peas (*Table 1.2*). The rate of increase in yield of vining peas has been substantial in the UK and even more rapid in Australia but at much lower levels (*Tables 1.1* and *1.2*). The rate of increase in vining pea yield is

Table 1.1 AREA, YIELD AND PRODUCTION OF GREEN PEAS FOR THE TWO 3-YEAR PERIODS 1969-71 AND 1979-81 IN DIFFERENT REGIONS. SOURCE: FAO, 1981

Region/Country	*Area* (1000 ha)		*Yield* (metric t ha^{-1})		*Production* (1000 metric t)	
	1969-71	*1979-81*	*1969-71*	*1979-81*	*1969-71*	*1979-81*
Africa	19	21	4.65	5.96	89	126
N. and C. America	192	171	6.52	7.57	1254	1300
Canada	20	19	2.89	3.67	57	69
Mexico	13	16	2.23	3.19	29	54
USA	160	136	7.32	8.64	1168	1177
South America	45	42	2.48	2.93	111	122
Asia	132	151	3.96	4.00	523	603
China	33	42	5.47	5.38	181	225
India	75	88	2.87	2.88	215	253
Europe	280	295	6.88	6.96	1926	2054
France	48	60	8.36	7.50	400	447
Hungary	30	35	5.03	6.09	152	215
Romania	16	28	2.66	2.56	41	71
UK	52	56	10.56	12.03	546	679
Oceania	30	23	4.96	6.83	147	154
Australia	21	14	5.58	7.83	117	111
USSR	57	67	3.04	3.73	174	251
World	755	770	5.59	5.99	4224	4610

not reflected in combining peas, possibly because of the substantially greater plant-breeding effort so far devoted to the former.

Although UK vining pea yield increased steadily for many years, the rate has slowed, and is now levelling off or possibly even falling, despite continuing technical advances; this may be attributable to a combination of agronomic and commercial factors.

Soil condition is thought to have deteriorated because of heavy equipment and untimely cultivation. In spite of adequate technical advice there has been over-cropping in some areas, resulting in the build-up of soil-borne diseases. The adoption of small-seeded and earlier-maturing peas has also tended to lower yield.

In the UK, the national hectarage of vining peas rose from 19 000 in 1955 to 57 000 in 1982. However, since then there has been no further growth as production appears to have reached the level of demand, a trend which is echoed in the USA (D. Bolingbroke, personal communication). Dried pea production fell from 49 000 ha in 1955 to 11 000 ha in 1962, but as a result of encouragement by the EEC to produce dried peas for inclusion in animal feedstuffs, the area had increased to 28 000 ha by 1982 and is continuing to develop. The combination of the lower standards of quality than those necessary in peas for human consumption, and the increasing availability of varieties with finer foliage, earlier maturity and improved standing ability, has led to expansion in the UK from the traditional pea-growing eastern counties of England, westwards to Cornwall and north to Scotland.

Table 1.2 AREA, YIELD AND PRODUCTION OF DRY PEAS FOR THE TWO 3-YEAR PERIODS 1969–71 AND 1979–81 IN DIFFERENT REGIONS. SOURCE: FAO, 1981

Region/Country	*Area* (1000 ha)		*Yield* (metric t ha^{-1})		*Production* (1000 metric t)	
	1969–71	*1979–81*	*1969–71*	*1979–81*	*1969–71*	*1979–81*
Africa	416	433	0.66	0.77	275	335
Burundi	38	31	0.80	1.19	30	37
Ethiopia	105	131	0.65	0.98	68	128
Morocco	61	49	0.64	0.48	39	25
Rwanda	76	60	0.85	0.78	64	47
Zaire	61	73	0.63	0.63	39	47
N. and C. America	160	131	1.64	1.95	262	255
Canada	32	47	1.35	1.76	44	84
USA	118	70	1.80	2.29	212	162
South America	138	146	0.73	0.71	101	103
Colombia	44	56	0.68	0.59	30	33
Asia	3138	2160	0.97	1.25	3055	2692
China	2100	1533	1.03	1.50	2167	2300
India	982	571	0.85	0.57	835	330
Iran	21	25	1.23	1.26	26	31
Europe	404	273	1.57	2.15	636	590
Czechoslovakia	14	31	1.62	2.11	23	64
France	12	26	3.31	4.13	38	107
Hungary	80	53	1.40	2.03	111	104
Poland	50	42	1.24	1.55	62	65
UK	25	36	2.96	2.96	75	107
Oceania	51	71	1.57	1.73	81	122
Australia	29	47	0.97	1.17	28	55
New Zealand	22	24	2.35	2.82	53	67
USSR	3316	4181	1.51	1.05	4989	4339
World	7624	7395	1.23	1.15	9399	8434

Research and development

Few crops have been subjected to more intensive research and development than peas, particularly vining peas, where controlled production of good-quality produce is essential. In the UK, the Processors and Growers Research Organisation (PGRO) specializes in conducting applied research and providing advisory services for pulses, and has made many contributions at home and abroad in this field over the last 40 years.

TYPES, VARIETIES AND USES

Choice of type and variety greatly influences product and tremendous efforts have been made by breeders in many countries to effect improvements. Many varieties used for processing up to the 1950s had been bred for garden use; they were designed to give the maximum number of separate pickings, whereas for mechanical harvesting uniformity of maturation was the aim (Gane, 1972a). Improved varieties have higher yields and better sieve size distribution.

Similarly, the move towards stiffer stems, lighter haulm and the concentration of pods at the top of the plant (as in fasciation) has improved throughput of expensive harvesting equipment. Such varieties, however, were a disappointment because in damp conditions, moribund petals fail to fall clear of the plant and are rapidly infected by grey mould (*Botrytis cinerea* Fr.), reducing yield and quality (Gane *et al.*, 1984).

Plant breeders, especially in the USA, have been successful in breeding varieties resistant to a number of important diseases; in this work, Brotherton, Gustafson, Pierce, Parker, Renard, Anderson and Walker were supreme and laid the foundations for many varieties to be used for a period of 50 years or more (H.W. Mauth, personal communication).

Notable successes were achieved in introducing resistance to pea wilt (*Fusarium oxysporum* f. *pisi*, races 1, 2, 5 and 6), powdery mildew (*Erysiphe polygoni* D.C.), pea seed-borne mosaic virus (PSbMV), pea enation mosaic virus (PEMV) and pea streak virus (PSV).

Breeders strive constantly, and not without success, to match the needs of processor and consumer in terms of yield, quality, reliability, maximum season and continuity of supply. Varieties of combining peas used for canning must not break down or gel, while water uptake is also a vital economic factor. Varieties of combining peas for animal feed, on the other hand, must primarily be high yielding.

Commercial production of sugar, snap or mangetout peas (*P. sativum axiphium* L.) is currently small, but breeding is in progress; stringless varieties have been produced which can be handled successfully by green bean plant and machinery. Yield appears to compare with that of green beans and the frozen product is said to be excellent (C. Lamborne, personal communication).

The most important change in varieties overall in recent years has probably been in haulm bulk. This has come largely from work which began at the John Innes Institute in 1969, and which was developed jointly with PGRO. 'Semi-leafless' and 'leafless' types were produced, the former having leaflets reduced to tendrils but retaining stipules, and the latter additionally having reduced stipules. The semi-leafless phenotype now appears to have the greater crop-plant potential.

The use of such plant types tends to improve the microclimate; the sparser haulm reduces competition with weeds, but efficiency of weed control compensates sufficiently. In combining peas, the development period is long enough for all peas on the plant to mature, so that a relatively wide distribution of pods is less of a disadvantage than in vining peas. Stiff stems are an advantage in both cases, helping to keep pods clear of the soil, reducing fungal infection and aiding harvesting.

In the 1970s a tare-leaved variety of marrowfat dried pea was produced by selection by PGRO and named 'Progreta', being something of an intermediate between the traditional marrowfat and a semi-leafless form. It has had marked commercial success in the UK and abroad and is currently the most popular variety in the UK.

Plant breeding has produced a wide range of varieties: over 1000 varieties of vining peas alone have been evaluated at PGRO over the last 10 years. Pea breeding is pursued in many countries and American, British, Dutch, French and German varieties are widely distributed. However, conditions in some countries are such that the best results are unlikely to be achieved merely by importing varieties from elsewhere. In South Africa (Transvaal), for example, 95% of the crop is sown with the American variety 'Puget' (S.E. Bosch, personal communication), but when grown in this region it is indeterminate and too tall, giving a laid mass of vegetation with much rotting. The authorities and commercial companies there have been advised to embark on their own breeding programme (Gane, 1972b), and are in fact doing so (P.T. Pickering, personal communication).

In India, Uttah Pradesh is the most important pea-growing state, and here varieties are used which originated in America, Sweden and the UK, as well as a number of local selections (CSIR, 1975).

GENERAL AGRONOMY

Crop rotation

Little precise information on the influence of crop rotation on peas and beans was available until recently in the UK, when it was suspected that over-cropping was a factor of yield decline and the subject was studied by PGRO. A survey of nearly 3000 crops of peas and beans was conducted in 1973–75, when the incidence of soil-borne diseases was determined and compared with previous cropping in each case.

The results showed that where peas or beans were grown on the same land only once or twice in 9 years, the incidence of such diseases remained low, that cropping three times in 9 years resulted in a marked increase, whereas four times in 9 years resulted in the incidence of disease being very much greater still. The results also indicated that the introduction of beans accelerated the build-up of pathogens even more than peas (Biddle, 1979).

In order to achieve the practical application of these results, PGRO developed an early-warning system to determine the degree of risk from soil-borne diseases in potential pea fields. Growers may submit soil samples from prospective pea fields and after greenhouse and laboratory tests, a foot-rot index is assigned to each field, indicating the degree of risk in growing peas there. The index is applied on a 0–5 scale, and the average loss from the footrot complex in 2 years' monitoring was 0.9 tonnes (or some £200) per hectare, for each increase of 1.0 on the index (Biddle, 1983).

The study stressed the need to avoid over-cropping and allowed us to determine the minimum safe rotation: the results emphasized that peas and beans must be treated as the same crop from the point of view of rotation; they prompted the development of a means of determining the relative risk of foot rot between fields in advance of sowing and enabled us to quantify the losses being incurred. Where soil-borne diseases are present as a result of over-cropping, a long-term problem is likely unless resistant varieties are produced; however, for new growers the adoption of an adequate rotation from the start will probably enable them to maintain yield levels for many years.

Where possible, the sensitivity of peas to poor soil conditions should also be taken into account when planning the rotation, to avoid following such crops as sugar beet, after which soil structure is likely to be poor because of the use of heavy equipment. Peas are considered to be the ideal precursor to winter wheat, which is able to take full advantage of the residual nitrogen.

Cultivation

The aim of cultivation in large-scale pea growing is to provide the best physical environment for rapid germination of seeds drilled at an even depth, rapid establishment and uninterrupted, unimpaired growth. Rapidity of germination is helped by close contact with reasonably fine moist soil. Rapidity of establishment is helped by a friable tilth, and uninterrupted or unimpaired growth demands good soil structure, freedom from capping and over-consolidation, and a sufficiently fissured profile to allow a free root run. Good drainage is essential for adequate oxygen supply to the roots (Crawford, 1979), without which nodulation is impaired. Peas are very sensitive to compaction, while clods and stones must be removed in the interests of weed control and harvesting.

It is also essential in the UK that the required seed-bed is produced early in the year, preferably in late February or early March, when weather conditions are often favourable for only brief periods and when the land is likely to be cold and wet. Much cultivation at this time often results in compaction and excessive wheelings, and there is a danger of making soil conditions worse rather than better; a fine seedbed is unnecessary, and is often positively detrimental. In a joint study of compaction by the University of Nottingham School of Agriculture and PGRO (Dawkins *et al.*, 1981), instances were recorded in which plant population in wheelings was reduced by 50% and yield was reduced by 65%. At one site, wheelings affected 25% of the surface, creating a loss of £1000 over 15 ha.

Manuring

The first comprehensive series of field trials to determine the manurial requirement of peas in the UK was initiated and conducted in part by the Home Grown Threshed Peas Joint Committee (HGTPJC) (now PGRO) (HGTPJC, 1949). The results showed that peas rarely respond to applied nitrogen, and that even when they do the response is small. Applied phosphates were beneficial only where there was acute deficiency in readily soluble phosphorus. Potash, on the other hand, was the most important of the three, applications resulting in yield increases in 18 of the 25 experiments, the degree of response relating directly to soil potash level. In these experiments, early application of broadcast fertilizer was essential for maximum response. Work by the PGRO on new varieties some 30 years later confirmed these results.

Sideband placement was found to be the most efficient method of application for peas in wide rows, but little benefit was derived from pre-drilling. Advances in weed control took place concurrently and interrow cultivation was unnecessary. Consequently crops were grown in narrow rows and sideband placement was hardly ever used.

Manurial trials have been carried out at many other centres (CSIR, 1975; Austensen and Drew, 1980), with broadly similar results, which may be summarized by saying that the manurial requirements are small, they are directly related to soil fertility and, for the greatest response, early application and incorporation are essential.

Inoculation

Inoculation with *Rhizobium* is unnecessary in the UK, but is essential in situations where the bacteria are not already present in the soil.

Seed and seed health

Pea seed should be of high germination capacity, free from diseases and disorders, and true to type in order to give uniformity at time of maturation and in shape, size and colour within the produce. Careful roguing and maintenance of seed stocks is essential. Some seed stocks deteriorate quickly and some breeders suggest that new stocks should be brought into use every 6 years (D. Bolingbroke, personal communication). The stocks should originate from the breeder or maintainer.

The most important group of fungus diseases affecting pea seed is the *Ascochyta* complex, which causes a seedling rot, a foot rot, flecking, spotting and streaking of the plant surface, produce spoilage and yield reduction. The complex may now be virtually eliminated from seed by treatment with thiabendazole, which is used in mixture with captan to control damping-off and other soil-borne diseases, a relatively new and very important advance (Biddle, 1981a).

Few virus diseases of peas are seed-transmitted to a serious extent, although there is currently concern over pea seed-borne mosaic virus (PSbMV); infected seeds have been found in breeding lines in many countries, and also in commercial stocks of seed in the UK. Satisfactory seedling establishment of combining pea varieties is readily attainable, but some seedlots of vining peas, particularly wrinkle-seeded types, result in partial crop failure despite good laboratory germination. The ability of seed to survive in adverse conditions is termed its vigour, and the electrical conductivity test has been developed to test for this factor, by measuring the salts lost into solution during imbibition. The test is used to differentiate between seedlots suitable for early sowing, seedlots which should only be sown in better conditions, and those which are unsuitable for use as seed. Studies at PGRO also demonstrated a direct correlation between vigour and seedcoat damage, of a type caused by threshing very dry, and therefore brittle, pea seed. The timing of threshing seed crops is thus a vital factor in avoiding low vigour (Biddle, 1981b).

Row width and plant population

The development of selective herbicides has eliminated the need to grow peas in wide rows, so that full advantage may be taken of the benefits of more even plant distribution. Extensive PGRO work on this subject showed that vining peas sown in 40 cm rows yield 20% more than those in 60 cm rows, while peas in 20 cm rows yield 24% more than those in 40 cm rows. With combining peas, a 39% increase in yield is likely to be obtained by reducing row width from 60 to 20 cm. With neither type of pea is there any advantage to be gained by reducing row width still further. Peas grown in the narrower rows are easier to harvest, and there is improved suppression of weeds by the crop canopy.

Extensive series of experiments have also explored the closely allied subject of plant population, and the two have been studied together under the heading of spatial arrangement. In the case of traditional forms of vining peas, yield rises with population reaching its maximum at some 120 plants m^{-2}, but the maximum economic yield is reached at around 90 plants m^{-2}, depending on seed costs (King, 1967). Combining peas reach maximum yield at around 95–100 plants m^{-2}, and maximum economic yield at around 65–100 plants m^{-2}, depending on the type of pea and seed cost (Gane *et al.*, 1984).

Achievement of target population

Achievement of target populations is of economic importance, since seed is expensive and the effect of variation from the optimum population is quite dramatic. Many factors influence population achievement, such as crop rotation, cultivation, seed health, germination, seed protection, soil type, time of drilling and so on, and a formula has been produced to take most, if not all, of these into account, to allow the achievement of plant populations to within very reasonable limits (Gane *et al.*, 1984).

Date of sowing

The succession of sowings necessary to allow orderly harvesting of vining peas at the appropriate stage of maturity dictates the date of sowing of each field or section, leaving no room to manoeuvre, but this is not so with combining peas.

PGRO trials at 47 centres, over a period of years and a range of soils, demonstrated the importance of the timing factor in relation to the yield of combining peas. On average, yield falls by some 100 kg ha^{-1} for each week's delay in drilling after the first week of March. In addition, early drilling gives earlier harvesting and better quality produce. Early drilling is vital in achieving maximum economic yield of combining peas. No extra cost is incurred, but it is necessary to select fields carefully, to plan cultivations, to prepare the land early and take full advantage of weathering, and to be ready to drill whenever an opportunity presents itself (Proctor, 1963).

Irrigation

The response of peas to irrigation is dependent on the availability of soil moisture and the stage of crop development, but the potential is very considerable and under-utilized in many countries. The greatest response occurs where there is a moisture deficit and when irrigation is applied as the first flowers are opening; a second but smaller major response occurs if irrigation takes place as the pods begin to fill. Rates of 50–75 mm on the first occasion and 25–50 mm on the second are adequate (Salter, 1963). Higher rates are not justified in the UK. Irrigation should not take place at the end of flowering, because of the risk of *Botrytis* infection.

There are side-effects, such as the disruption of sequential harvesting in vining peas, and the encouragement of weeds, but the most common reason for failure to irrigate peas in the UK is that other crops are given priority in terms of water and equipment.

Drought is a limiting factor in the South Eastern Cape and Pretoria provinces of South Africa, and the Canterbury area of New Zealand (Logan, 1983) and irrigation is practised, whereas in parts of Queensland, Australia, irrigation is highly desirable but water is not available (O.J. Olivier, personal communication).

Elsewhere, production areas and the processing season have been successfully extended because of the availability of irrigation. For example, in the USA, in Western Washington, pea growing has been extended into the Columbia Basin and peas are also grown under irrigation in Wisconsin. Most of the Mid-West and Eastern peas are grown under low rainfall conditions, but in California this is supplemented by irrigation (H.W. Mauth, personal communication). In short, irrigation can play a significant part in pea production and it is not yet fully utilized.

WEED CONTROL

The need for reasonably efficient weed control in arable crops is well known. Competition for nutrients, moisture and light is an important factor because, if weed growth is unchecked, yield is often reduced. With some crops, this appears to be the only reason for weed control, but in pea growing it is one of a number, and is not necessarily the most important one (Gane, 1968).

In one series of 15 weed-control trials in peas, over 6 years, the mean yield increase by the then standard application of dinoseb-ammonium was 376 kg of vining peas per hectare. Wild oats, on the other hand, have been known to infest pea crops sufficiently to halve the yield. In addition to these severe effects upon yield, viner throughput is reduced, some weeds serve as hosts for disease organisms, but most important is the fact that weed fragments in the produce may cause rejection of vining peas by the processor, resulting in total loss.

Some plant parts, such as poppy (*Papaver rhoeas* L.) and mayweed (*Matricaria* and *Tripleurospermum* spp.) flower heads, and black nightshade (*Solanum nigrum* L.) and white bryony (*Bryonia dioica* Jacq.) berries, are difficult, if not impossible, to remove mechanically from vined peas. Heavy weed infestation in combining peas slows down the all-important maturation and field-drying process. Some weeds in other countries are even more undesirable, such as the devil's thorn (*Emex australis*), the spiked seed of which can be dangerous as a contaminant.

Until the 1950s, in developed countries weed control in peas was effected by cultivation, harrowing and mechanical hoeing between the rows. While effective to a degree, harrowing damages pea leaves and encourages the entry of fungus diseases, notably downy mildew (*Peronospora viciae* [Berk.] Casp.), while interrow cultivation often damages root systems and in dry weather results in moisture loss. Hoeing has been known to reduce vining pea yield by 29.5% (Gane, 1972a).

By 1949, the search was on for selective herbicides in peas. PGRO's first trials compared MCPA powder with the ammonium salt of dinoseb, and in fact the latter was used successfully for many years. A host of materials have since been developed and one of PGRO's main roles has been their evaluation, in relation to weed control, crop damage and varietal sensitivity. The control of broad-leaved weeds by post-emergence treatments came first, and was followed by soil-acting materials such as prometryne. After 11 years' work, recommendations were made for the control of wild oats (*Avena fatua* L.) in peas, and later treatment for the control of couch (*Elymus repens* L.Gould) became available too (Knott, 1982).

At one time, peas were a notoriously weedy crop, but the introduction, development and continual refinement of selective weed control means that they may now be classified as a cleaning crop. It is still wise to reduce weed infestation by good ploughing, but there are few instances in which there are uncontrollable weed infestations in peas. The choice of herbicides is most important in relation to weed flora, soil type and variety, but ample guidance is readily available (Gane *et al.*, 1984).

PESTS

In the early stages of its development, pest control was concerned very largely with the search for insecticides which would control various species. More recently, far more emphasis has been, and is being, placed on the economics of pest control and upon treatment timing.