(Photo Zaven Grigoryan, Genebank NAS, Republic of Armenia)

Vetches: from feed to food?

Les vesces : vers une valorisation alimentaire pour l'homme?

Narbon bean (*Vicia narbonensis*).

In matters agricultural, it is useful to compare; the new with the ancient, the northern hemisphere with the southern, the good with the bad, the poor with the rich, the triumphs with the fiascos and to glean from all these differences, those practices that have advanced civilisations and those that have not.

In this special issue devoted to the role of vetches (*Vicia* spp.) in agriculture, we have selected examples that are ripe for a concerted effort, not just to modify their genetic composition, but to use all the skills we have as scientists and agriculturalists, to raise these extraordinary legumes to a higher plane of usage and economic value for everyone.

Our first article outlines the general approach including historical reasons why we should not believe everything we read in the papers be they by journalists or scientists. The section on global vetch production estimates their economic role. It also illustrates how a few, well chosen words in a prestigious journal like *Nature* can (eventually) stop a deceptive export industry and prepare the way for a sound and more rewarding industry.

In the common vetch (*Vicia sativa*) and the narbon bean (*Vicia narbonensis*) articles, we suggest, that modification of the antinutritional content of these two species, will not only provide us with all their inherent agronomic diversity to cope with current climatic changes, but additionally provide two immense new food sources. The final article shows how Turkey is approaching the problem of changing the short-term mindset of continuous cereal cropping with attendant disease problems, to one in which the introduction of early-maturing vetches and chicklings (*Lathyrus* spp.) can raise the productivity and financial well being of individual farmers. ■

Dossier coordinators: Dr Max E. Tate and Dr Dirk E. Enneking.

Dans le domaine agricole, il est utile de comparer, le nouveau avec l'ancien, l'hémisphère nord avec le sud, le bon et le moins bon, le pauvre et le riche, les succès et les fiascos, et à travers ces différences, de glaner les pratiques qui ont fait progresser les civilisations et celles qui ne leur ont pas été bénéfiques.

*Dans ce dossier sur le rôle des vesces (*Vicia *spp.) dans l'agriculture, en tant que coordinateurs du dossier, nous avons sélectionné des exemples qui sont le fruit d'un effort collectif, visant non pas simplement à modifier la composante génétique de leur composition mais à utiliser toutes les compétences des scientifiques, agronomes et agriculteurs pour apporter une meilleur usage et une meilleure plus-value à ces extraordinaires légumineuses dans l'intérêt de chacun.*

Le premier article brosse le tableau général rappelant les raisons historiques du pourquoi il ne faut pas croire tout ce qu'on lit dans les écrits, qu'ils soient de journalistes et de scientifiques. Ensuite la présentation de la production mondiale de la vesce permet d'évaluer son rôle économique. Elle illustre aussi comment quelques mots bien choisis dans un journal prestigieux comme Nature *peuvent (éventuellement) stopper une industrie exportatrice illusoire et préparer le terrain pour une industrie plus cohérente et rentable.*

*Par ailleurs, nous analysons pourquoi la modification de la teneur en facteurs anti-nutritionnels de la vesce commune et la vesce de Narbonne va non seulement nous faire profiter de leur diversité agronomique inhérente pour faire face aux changements climatiques, mais également nous pourvoir de deux nouvelles sources alimentaires pour l'homme. L'article final montre comment l'approche utilisée en Turquie, pour passer de considérations à court terme favorisant les monocultures de céréales avec les problèmes de maladies qui les accompagnent, à l'introduction de vesces à maturité précoce et de gesses (*Lathyrus *spp.), permet d'améliorer la productivité et la qualité de vie des agriculteurs. ■*

Vetches: from feed to food?

Les vesces : vers une valorisation alimentaire pour l'homme?

by Max TATE* and Dirk ENNEKING**

Food, feed or weed? Vetches can be all of these things, to nearly all people, depending on the time and the place. To simplify the following series of articles we have limited our discussion to annuals of the genus *Vicia*. This excludes its perennials and vetches in the genera *Lathyrus* and *Astragulus*. To delineate the topic range, we have restricted it to Europe and Australia. We realise that this dossier can only provide a brief introduction to the tremendous treasure of information, which has accumulated since antiquity for these crops and potential domesticates.

We believe that some vetches can be developed in a way similar to that used for lupins in the 1920s (6) and are interested in their improvement to the stage where they become suitable as pulses (soup legumes) for use by vegetarian societies in particular.

A 'career path' for vetches

History tells us that the standard progression of any species of *Vicia* in agriculture is its initial use as a producer of biomass, or its recognition as a contaminant of other crops. From there, it evolves to fill various niches, as a desirable crop plant or a persistent nuisance. Due to a potent mix of antinutritional factors in various parts of the plant, its use as a feed tends to be restricted to ruminants, although pigeons are often cited as being fond of vetch seed.

The greatest obstacle in the hypothetical 'career path' from vetch to pulse, is the presence of non-protein amino acids and other heat-stable antipredator toxins, that have evolved in the seeds.

Versatilility for farmers

The economic importance of vetches is based on their versatility for farmers and the immense diversity of available germplasm that underpins their widespread adaptation (3). From acid (*V. villosa, V. articulata* Hornem.) to alkaline soils, dry to waterlogged, autumn or spring sowing, the different species with their genetic variation offer considerable latitude to cultivators. The best soils for vetch are well-drained (not water-logged), lime containing, clay and loam soils. Sandy soils are, with some exceptions, such as *V. villosa*, less suitable (2, 3). Biomass and seed production, abiotic- and biotic-stress tolerance, management flexibility and low input requirements are the principal attributes that have attracted farmers throughout the ages to grow vetches. The available data for vetch production around the world is discussed in one of the following articles to provide an economic perspective.

The high nitrogen fixing ability of *V. villosa* (1) gives reason to think about this trait as a specific breeding objective for other legume crops, which have been domesticated for much longer (5).

The breeding of vetches, was last reviewed in detail by Lechner (4). Cultivars were developed for several species and much of this 'enhanced germplasm' has found its way via national genebanks, such as the important vetch collection in Gatersleben, Germany, into international collections, where their cultivar status is not always recognised. Hence any claims of breeding successes with so-called 'wild' *Vicia* germplasm may need to be revised once the original source(s) of germplasm can be ascertained, if necessary, by follow up of donor information and molecular phylogenetic fingerprinting techniques.

(Photo CRIFC, Ankara, Turkey)

Pre-basic seed production of hairy vetch (*Vicia villosa* ssp. *villosa* variety Selcuklu 2003) at the Central Research Institute for Field Crops (CRIFC), Ankara, Turkey.

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(Photo CRIFC, Ankara, Turkey)

Narbon bean (*Vicia narbonensis*).

Mansfeld's database in Gatersleben (http://mansfeld.ipk-gatersleben.de/) lists 17 cultivated *Vicia* taxa, with use for fodder [7], forage [12], animal feed [3], experimental purposes [7], famine food [1], food [8], pasture [11], pasture crops [3] and scientific use (lectins) [1].

Some of these were never taken into commercial production, but repeated attempts were made during the nineteenth century, and these efforts demonstrate the continual efforts to harness the productivity of wild and weedy vetches for agricultural purposes. The large number of species listed for food use (apart from *V. faba*) may need some adjustment.

There is good historical evidence that in times of famine, our ancestors turned to these nitrogen rich legumes with 20–30% crude proteins (in *Vicia* from 2–7% of this 'protein' actually consists of non-protein amino acids) to nourish themselves and their livestock. For example, Philostratos describes how Apollonius came to the town of Aspendus in Pamphylia where he found nothing but vetch (Orobos = *Vicia ervilia*) on "sale in the market, and the citizens were feeding upon this and anything else they could get; for the rich men had shut up all the corn (cereals) and were holding it up for export from the country". Clearly, food substitution with vetches has had a long record but detoxification would have had a significant role to render such famine foods edible. In Hellenistic Egypt specific vetch sellers existed, presumably to carry out the leaching and detoxification business.

Livestock losses through vetch toxicity: recent domesticates

Livestock intoxication by vetches continues to be reported. The main vetch species implicated are *Vicia villosa* and *Vicia benghalensis,* both recent domesticates and characterised by high levels (2-3%) of the toxic amino acid L-canavanine in their seeds. From the onset of flowering onwards, the levels of this arginine analogue increase and make the utility of these crops as feeds, in the absence of alternative fodder sources, a risky business. In contrast, ancient crops such as *V. ervilia* have very low levels of canavanine in their seeds, but for this species chemically uncharacterised , water soluble bitter components require leaching prior to any possible food usage. Common vetch (*V. sativa*) can be cyanogenic and contains some additional toxins in its seeds. A separate article in this dossier provides an update on the development of non-toxic strains. The cyanogenic strains have frequently been implicated in stock losses. Generally, such losses occur more frequently when vetches are introduced as novel crops into new areas and new uses. Clearly, extension agents can learn a lesson from this but more research is also needed to identify optimum management practices to prevent further intoxications by canavanine type vetches. For details see reference (8) on page 19.

High levels of sulphur amino acids, the flavour of narbon beans

The narbon bean (*V. narbonensis*) has had, and continues to have a chequered history as far as its acceptance, either as feed by animals or food by humans, is concerned.

The narbon article in this vetch series reveals observations made by early European botanists and how this provided some clues to modern research. It also notes the extraordinarily high levels of sulphur amino acids in the seeds of narbon beans and why we consider it is worthy of closer investigation by all investigators.

There is considerable interest in the narbon bean in Turkey (see pages 20–21) and it has not been entirely overlooked as a potentially useful crop in rotations in Western Australia and Spain. In part, this renewed agronomic interest in narbon bean, is centred upon its remarkable tolerance to abiotic and biotic stresses.

The very real possibility, that the toxic famine food known as common vetch, can have its cyano-alanine toxin level reduced to a level that is tolerable to poultry, which are the most sensitive indicators, is being actively investigated in Turkey and Australia and is discussed on pages 16–17. Given that it took several decades to convert the toxic rapeseed into what is now known as Canola, we are of the opinion that there are good prospects for doing the same thing with *V. sativa* even though considerable research effort is still required.

However, the short-term nature of political and corporate memories revealed in some of these vetch items, inevitably leads to repetitive mistakes in their usage. Fortunately, the clarity of hindsight afforded by better statistics in agriculture, show us what have been sensible and what have been foolish ventures in global vetch production. The occasional historical perspective as exemplified in the narbon article, can also provide unexpected enlightenment and provide clues to important work, which still needs to be done, so that these frequently neglected, but inherently valuable legumes, can provide us with plan 'B' to handle both biotic and abiotic stresses caused by the approaching climate changes that lie ahead. ■

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Global vetch production

La production mondiale de vesces

by Dirk ENNEKING* and Max TATE **

Vetch in the strictest sense is *Vicia*. Commercially this comprises *Vicia sativa* (common vetch) and *Vicia villosa* (Winter vetch, hairy vetch), with some species having local significance such as *V. pannonica* in Turkey, *V. ervilia* and *V. articulata* Hornem. in Spain and *V. benghalensis* in Australia. It is instructive to compare different data sources and make a distinction between production and uses. Even the term 'vetch' sometimes refers to an entirely different species in Africa.

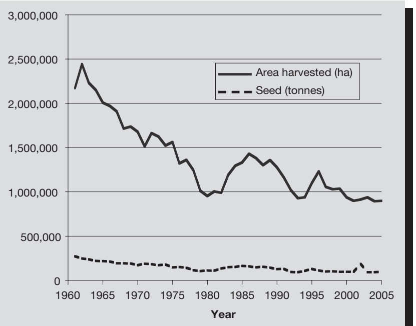
For example, before the Second World War, Fischer (1938) sketched a picture of vetch production in Europe. Countries like Germany, Austria, Bulgaria, Lithuania and Spain cultivated vetches as grain- and fodder crops. In Great Britain, Hungary, Yugoslavia, the Netherlands and Sweden, vetches were only cultivated as green forage. In Czechoslovakia they were mainly cultivated as grain crops. Germany in 1937 produced 132,321 ha of vetches (4).

Vetch production in Eritrea and Ethiopia refers to the cultivation of grasspea (*Lathyrus sativus*), a different species entirely! Data from other countries may include this and other species such as *L. cicera*, *L. tingitanus* or *L. ochrus*.

Significant under-reporting

Production statistics for vetches from FAO (Figure 1) supposedly indicate a global decline in vetch production (area harvested) since the 1960s.

A closer look at data from individual countries suggests that significant areas of production are under-reported or amalgamated under other headings such as animal feed (forage) and pulse production (dry seed). For example, since 2002 no separate vetch production data has been recorded for Australia. For the USA, where *V. villosa* is a widespread catch crop and is even used in preference to plastic as a mulch for 'power tomatoes', vetch production does not feature at all during the 45 years covered by FAO records. Neither are there any figures from China under this category.



Source: FAOSTAT, September, 2006

Figure 1. Global vetch production (area harvested).

A comparison of FAO production figures (area harvested) for the years 1961 and 2005 reveals that there are some countries in which reported vetch production has remained stable (Turkey, Lebanon, Albania and Syria), several with a precipitous decline (Bulgaria, Greece, Cyprus, former Czechoslovakia, Poland, Algeria), others with roughly a quarter of former production (former USSSR, former Yugoslavia, Italy, Malta) and even some with substantial increases (China, Spain, Australia).

According to these figures, the largest decrease (1.13 million ha) has occurred within the area of the former USSR. Vetches are well adapted and native to the Central Asian and Caucasian republics, so it is highly likely that production from these countries is presently under reported. Therefore not all of the former USSR vetch production has necessarily been lost, it is just not being adequately reported.

For China some information can be gleaned through Google. In 1998 *V. villosa* was cultivated on 124,000 ha and *V. sativa* on 99,000 ha (6). This puts China into the top ranks of vetch producing countries. Anyone driving through Yunnan province during spring can witness the widespread cultivation of *V. villosa* because purple flowered fields are aplenty on a drive south-west of Kunming.

Dramatic increase in Australia

Figure 2 shows that Australian vetch cultivation, increased dramatically after the early 1960–80s plateau. This came about through Australian agricultural experts returning from Jordan, where they were meant to introduce the ley farming system based on medic and clover cultivation. The Jordanian farmers were not that impressed with the idea of planting something that was so close to the ground that it did not look like a crop and hence under their customs permitted everyone to graze their flocks on it.

In Jordan they preferred to grow vetch crops that could be grazed only by permission and so no fences were needed. With everyone adhering to these customary taboos, feed production was just fine. The Australian advisers were so impressed with the vetch productivity in Jordan that they promoted such cultivation in their homeland (2). Luckily, other visionaries had preceded them by several decades so that they could draw on cultivars already released during the 1950s by Eric Bailey of CSIRO at Muresk, Western Australia.

A cultivar with orange cotyledons

Among Bailey's releases, was one cultivar (Blanche fleur) with orange cotyledons which when split closely resembled red lentils. Figure 2 shows that from the late 1980s, the gold rush was 'on', primarily

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due to Blanche fleur vetch exports for sale as a cheap substitute for red lentils, consequently production dramatically increased. The two sharp collapses of the Australian vetch harvest after 1992 and again in 2000 (Figure 2) correlate perfectly with two articles in *Nature* in October 1992 and July 1999 that drew attention to the folly of the continuing export of red split vetch as a cheap substitute for red lentils (see also page 16–17).

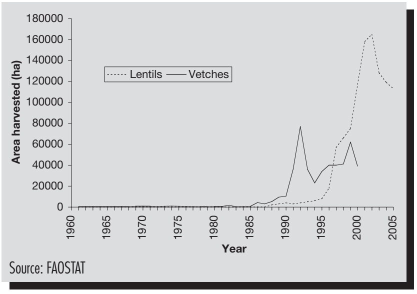

Figure 2 Areas of lentils and vetches harvested in Australia between 1960 and 2005.

With the aid of a ban on split vetch exports in 2003 to protect lentil exports, sanity returned, and since then the area of vetch cultivation has remained significant and currently (2006) appears to be expanding more and more into hay production due to the release of successful rust resistant *V. sativa* cultivars such as Morava. The current estimated area for South Australia is 25,000 ha, and in the south-eastern state of Victoria a larger amount is grown, perhaps 50,000 ha, in what was originally 'Mallee' (a type of eucalypt tree) country. Adding New South Wales, Western Australia and Tasmania, the total area sown to vetches easily exceeds 100,000 ha. One vetch report suggests an estimated area of more than 250,000 ha for the past five years. It remains to be substantiated whether this is a cumulative or an annual figure. The 2006 Australian census data should provide the correct figures.

Spanish statistics reveal political intervention

A second example demonstrates how more reliable statistics can provide an interesting hindsight picture of political intervention. The detailed production figures for individual species are available from Spain (8) from 2004 and are plotted in Figure 3. The cumulative figure of 281,940 ha for Spanish vetch production in 2003 does not match with the FAO reported harvested area of 166,600 ha. In addition, the Spanish Ministry of agriculture, fisheries and food (MAPA) provides details on vetch forage production in 2003 (59,700 ha) (8).

It is not clear whether the area for vetch forage is included in MAPA's production figures for individual grain legumes species, or whether they should be added. If added, the total vetch production for 2003 would be 341,640 ha. However, it is clear that forage cultivation in Spain has declined steadily between 1990 and 2003.

The remarkable peak in the area sown to *V. sativa* in Figure 3 is readily understandable, once the political imperatives are taken into account. Production of vetches in the EU has received financial support since 1996. In 1989, EEC regulation No. 762/89 provided support for grain legumes. It was extended by Regulation (EC) No. 1577/96. A maximum guaranteed area (MGA) is subsidised outside of the arable crops scheme. Regulation (EC) No. 811/2000 divided the MGA between chickpeas and lentils (human consumption) and vetches (animal feed). This translates into aid of €181/ha and a MGA of 160,000 ha for chickpeas and lentils and 240,000 ha for vetches. Proportional adjustments to paid subsidies are made according to MGA size, after the combined area has been exceeded. The area for vetches was quickly exceeded. For example, in 2002/03 it amounted to 315,000 ha and consequently payments were reduced to €150/ha (3).

Eligibility for single farm payments

The common agricultural policy reform of 2003 has brought changes to these support schemes. Vetches are now eligible for the same single farm payments as for other forms of production. Since with the previous scheme, the area of production was exceeded it is now likely that the seeded area for vetches may increase again (1)

In the USA, vetch seed production was 1800 t in 1987, 2600 t in 1992, 600 t in 1997 and 270 t in 2002 (5). Depending on the seeding rate (30–70 kg/ha), the seed produced in 1997 would have been sufficient to sow 40,000–90,000 ha. The upper figure

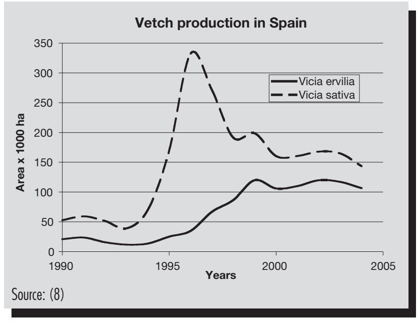

Figure 3. Vetch production in Spain.

approximates to a separate estimate of 100,000 ha for vetch production in the USA, with the main areas in the Pacific Northwest, Midwest, South and Southwest (7)

Global seed production for vetches has been estimated at 16,197 t for 2005 (5)

So from all these under-reported statistics, it is immediately clear that plots such as Figure 1, must be looked at with considerable skepticism!

In conclusion, the adjusted figure based on the discussion above for the global area of harvested vetches is 1.25 million ha. This is 58% less than in 1961 and most likely a less than fair proportion of actual global vetch cultivation. Vetches as a group are still a significant global crop. ■

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SPECIAL REPORT
VETCHES: FROM FEED TO FOOD?

Common vetch (*Vicia sativa* ssp. *sativa*): feed or future food?

La vesce commune (Vicia sativa ssp. sativa) : pour les animaux ou demain pour l'homme?

by Max TATE* and Dirk ENNEKING**

Common vetch has small seeds generally 20–90 mg, with a protein range of 240–320 g/kg. However, like most legumes it has evolved a range of nitrogenous antinutritional factors (ANFs), (β-cyano-L-alanine, its γ-L-glutamyl peptide, the cyanogenic glycosides vicianine and prunasin, and also the favism toxins vicine and convicine, that are common to faba bean). The total N content is boosted by these components.

ANFs are a major constraint for monogastric consumption

As in the case of narbon bean, it is the ANFs of common vetch, that are the major constraints to its use as a monogastric feed stuff or in some circumstances as a famine food. Otherwise it is a very useful grain legume. Thanks to an early quantitative study of cyanogens (5), it is known that one well-adapted line, Blanche fleur, grown extensively in Australia, is devoid of the cyanogenic glycosides. It does, however, have a significant (1.3–1.6%) cyano-alanine toxin content.

The major collection of germplasm for economically important *Vicia* is held at ICARDA, Aleppo Syria (14). The ICARDA germplasm data used for Figure 1 shows that in both *V. sativa* ssp. *sativa* and also ssp. *nigra* accessions, there is an inverse function between seed size and cyano-alanine toxin content, as measured by diffuse reflectance infrared spectrometry (2). The more toxic subspecies *nigra*, is characterised by much smaller seeds (10–60 mg).

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Is a common vetch seed with zero cyano-alanine toxin possible?

Figure 1 plots more than 1,600 accessions (*V. sativa* ssp. *nigra* (156) and ssp *sativa* (1457)), with paired values of 1000-seed weight (g) (= average seed mass (mg)) and % cotyledon cyano-alanine toxin content. The significant (<0.0001) negative correlations for both *V. sativa* subsp. *sativa* and subsp. *nigra* can probably best be accounted for by assuming that some accessions have a fixed amount of toxin per seed, and that this toxin is diluted gradually in accessions with larger seed masses.

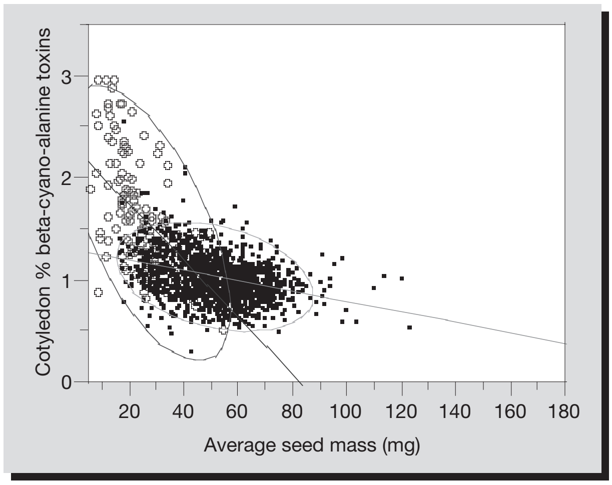

Figure 1. Bivariate normal ellipses (*P* = 0.950) of the average seed mass (mg) *vs.* the cotyledon % cyano-alanine toxins of 156 accessions of *V. sativa* subsp. *nigra* (open circles) and 1457 accessions of *V. sativa* subsp. *sativa* (squares) sourced from ICARDA, Aleppo, Syria.

Figure 1 shows that although not one genuine, zero cyano-alanine toxin, *V. sativa* accession was found, it also suggests the intriguing conclusion, that a near-zero % cyano-L-alanine toxin cultivar, might be obtained from the cross of a small seeded *V. sativa* ssp. *nigra* with a large seeded *V. sativa* ssp. *sativa*. F2 seed, that has been grown by H. Firincioglu in Turkey, to test this hypothesis will be analysed shortly.

The importance of minimising the content of cyano-alanine toxin in common vetch especially for feeding monogastric animals, stems back to the pioneering work of Ressler in the 1960s (6) and again later (7). Another study of antinutritional as well as synergistic effects observed in poultry fed with common vetch was published by Farran *et al* in 2001 (4).

Red split vetch/red lentil substitution has been stopped

Because of the similarity in appearance of the split orange cotyledons of some accessions (for example, Blanche fleur), to the cotyledons of the red lentil (*Lens culinaris* Medik), there have in the past, been repeated attempts (12, 13) to substitute red split vetch for the red lentil in third world markets. In 2003, the Australian government, made it a criminal offence to export split vetch, and the vetch/lentil substitution problem has apparently ceased. An indirect benefit from the demise of the vetch for food export industry is that Australia is now the third largest exporter of the highly valued, genuine red lentils, in the world (3).

Recent pig experiments

The adverse effects of some *V. sativa* accessions to poultry, ducks and pigs are well known, but recently, a well-controlled experiment, with 312 male pigs, (1) has demonstrated that one Australian *V. sativa* cultivar, Morava, could be fed to grower pigs at levels up to 225 g/kg of the diet without serious effects on growth performance being observed between 91 and 118 days. However, a significant negative linear response was observed between 119 and 161 days with a measurable voluntary feed intake decrease from 2.62 to 2.44 kg/day. Dietary differences due to the meat–meal content may have been a contributing factor to this decrease.

Unfortunately, no measurements were attempted on the cyano-alanine toxin content, either of the diet or the pig livers. Independent measurements in Adelaide with West Australian 2004 and 2005 samples of Morava vetch, gave cyano-alanine toxin contents for the cotyledons of 10.4 +/– 0.8 g/kg (mean +/– s.d.) and 9.7 +/–0.8 g/kg, respectively.

Although it is not possible to link the cause of the observed voluntary feed inhibition during the latter stages of the pig feeding trial to the cyano-alanine toxin content alone, any decrease in feed intake is a definite antinutritional factor warning sign for those promoting common vetch for human consumption.

Possible adverse effects

Confirmatory evidence for the neuro-toxicity of the cyano-alanine toxins has been provided (9). Currently the only report, of human cases of spastic paraplegia, induced in malnourished individuals, was that described by Shah in 1939 to the consumption of *V. sativa* seeds, present as contaminants in samples of stored wheat (10). This rather dated paper is important, because of the care taken to obtain an authoritative botanic opinion from Lahore, in order to properly identify the assumed causal agent as *V. sativa* alone.

There are two recent publications from the Ressler laboratory, concerning the antinutritional components of common vetch. The first (11) deals with the content of cyanogen, vicine, and beta-cyano-alanine toxins in a common vetch food, and their removal. They are essential reading for anyone wishing to use common vetch as either feed or food. It is noteworthy for drawing attention to the possible adverse synergistic effects due to cysteine sulphur depletion by the content of cyano-alanine toxins and cyanogens. The second (8) deals with urinary excretion of thiocyanate in a rat model. These studies suggest that all animals consuming sulphur deficient diets are likely to be affected adversely by the combined effects of sulphur depletion *via* thiocyanate and cystathionine excretion, induced by the consumption of toxins in common vetch.

Unless it can be demonstrated unequivocally that proteinaceous factors are also important, the literature to date suggests, that to produce a successful monogastric feedstuff from *V. sativa*, both the cyanogen and the cyano-alanine content must be minimised and excessive sulphur loss, induced by any residual vetch toxins, should be compensated for. Success with these objectives, could lead to the rapid adoption of low-toxin cultivars of common vetch, which are bred specifically for pig nutrition. For poultry nutrition, minimisation of the favism toxins vicine and convicine must also be achieved.

An enormous potential, monogastric feed and food source

As is apparent, from the article on the global production of vetches on page 14, there are enormous areas, already allotted to common vetch throughout the world, that are currently used primarily for forage, haymaking, green manure and as a grain feed for ruminants. These data, suggest that there will be an equally enormous feed resource for monogastric animals, once the content of antinutritional components has been minimised.

It is already well established that poultry are the most sensitive indicators for vetch toxicity (4, and references therein). However, for commercial feedstuffs where lowest cost formulations are practised, it is generally not economically feasible to use costly, small-scale post-harvest treatments such as extraction and autoclaving to produce a useful high quality feedstuff. The only practical recourse is to reduce permanently the levels of antinutritional factors by suitable plant breeding strategies.

The goals for useful cultivars, which also means well adapted lines of low toxin *V. sativa*, that provide high yields (>2 t grain /ha) and are suitable for monogastric consumption, are now clearly defined. Exactly which is the best and fastest way to get there, either by screening the products of classic plant breeding from the glasshouse and the field or alternatively the screening of genetic modifications produced in a Petri dish, followed by growth chamber experiments and ultimately by field experiments, only time will tell, and markets will decide. There is clearly a lot of plant breeding work to do in the years ahead.

The experience from the 1960s in Canada, with the production of lines of rapeseed, which also minimised two toxins (erucic acid and glucosinolate) to provide us with canola, shows us exactly what can be done. ■

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SPECIAL REPORT
VETCHES: FROM FEED TO FOOD?

Narbon bean (*Vicia narbonensis* L.): farmer's dream or devil's bean?

La vesce de Narbonne : le rêve de l'agriculteur ou la fêve du diable?

by Marina Arias ROYO*, Max TATE* and Dirk ENNEKING**

Narbon bean, mouse vetch, moor's pea, or devil's bean, are all common names (8) for this intriguing vetch species (*Vicia narbonensis* L.) which has an upright growth habit and is well adapted to Mediterranean and adjacent climatic regions (2). It was formerly believed to be the progenitor of the faba bean (*Vicia faba* L.) but molecular studies have refuted this idea.

Different botanical varieties are differentiated primarily by seed size. Both *V. narbonensis* var. *aegyptiaca* and var. *narbonensis* seeds could easily be mistaken for peas. The larger var. *aegyptiaca* types have been found in Turkey near Tunceli, in Lebanon in the Bekaa Valley and in Andalucia, Spain. Sicily and southern Italy are sources for agronomically interesting var. *narbonensis* types (7, 8). In Spain, narbon bean was largely neglected for a long period and is now found only in certain areas in Extremadura, Castilla La Mancha and Andalucia. However, thanks to recent studies there has been a revival of Spanish interest in this neglected crop.

Some agronomic virtues?

In the 1980s an Australian agronomist, David Georg championed the species as a potential new grain legume for dryland cropping. Ali Abd El Moneim and colleagues at ICARDA screened the available germplasm for grain and forage production in the Middle East and North Africa. A small-seeded variety IFVI 67, originally collected from Arbil in northern Iraq by Barry Bull and colleagues continued to give astounding agronomic performances under adverse conditions. Other promising material, originally collected by Geoffrey Hawtin, originated from a single population in the Bekaa Valley. In Spain during the drought of 1992, 900 kg seed/ha were harvested in Castilla y León, when all other legumes were close to zero yield. Seed yields of some varieties exceeded those of peas (4, 12 and references therein). Cultivars Gran Velox and Gran Veliero have recently been released in Italy and cultivar Tanami in Australia.

Has it been a food?

In Belgium, Dodoens (1583) noted if the seed is chewed, " it filleth the mouth full of stinking matter". However, Camerarius (1586) described the taste of the seed as similar to broad beans. The picture depicted by Camerarius appears to be of *V. narbonensis* var *aegyptiaca*. In accord with Dodoen's view, the Arabic name for the narbon bean, is Habb Adh-Dhurât (devil's bean). In Australia, the German botanist Baron von Mueller (1881) advocated the use of *V. narbonensis* as food. He found the seeds to be "preferable to *V. faba* because the somewhat smaller seeds were less bitter". In the light of current knowledge this may reflect the low seed levels of the bitter favism glycosides vicine and convicine. In eastern Turkey plants are pulled from lentil fields and their seeds are included in stews or chewed as a snack when green. However, overall, the human consumption of narbon beans and related species is sporadic and of no commercial significance (7, 8).

Definitely used as an animal feed

Mateo-Box (11) provides a comprehensive account of *V. narbonensis* as a crop plant in Spain. The grain was crushed and fed to cattle, especially calves. There are some issues with milk taint and initial feed intake (see 8 for detailed translation). There are frequent references to grazing animals (sheep and cattle) not being too fond of narbon plants and seeds, with evidence for selective feeding on preferred plant parts (6). So it is not only humans who are fussy about consuming it. A lowered palatability may be a good thing for the feeding of maintenance rations during droughts and to prevent bird or mouse damage; for animal production dependent on rapid growth rates (e.g. lambs), narbon beans would need to be made more palatable (10). Similar to the well known story of favism in humans, an intriguing link exists between the genetic makeup of the red blood cells of some sheep races, particularly those selected for wool production, and their susceptibility to sulphur containing feeds such as kale (*Brassica*) (see 7 for details). Does the palatability of narbon beans to sheep follow a similar pattern; are some breeds less tolerant than others?

Future potential?

In times of imminent climate change, it is timely to stimulate wider scientific interest in this remarkable plant. It is noteworthy that, with the exception of

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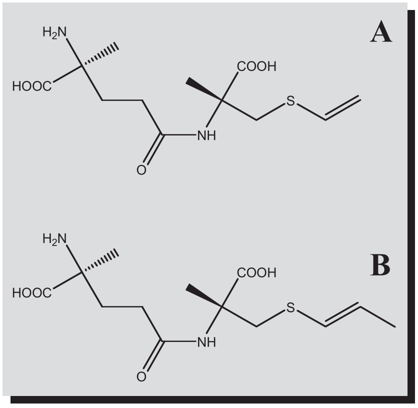

Figure 1. Structure A. The narbon off-flavour precursor (gamma-L-glutamyl-S-ethenyl-L-cysteine), Structure B. The chives seed aroma precursor (gamma-L-glutamyl-S-propenyl-L-cysteine).

some lupins, virtually all other legumes are low in sulphur; the narbon bean with a range between 2.8–3.6 g/kg total sulphur, is not.

One reason for this anomalous sulphur condition and low palatability is now known to be the presence of high concentrations (4–38 g/kg) of the 'garlic-like' stench precursor γ-glutamyl-S-ethenyl-L-cysteine (GEC) (9). The chemical structure (Figure 1A) of this apparently disadvantageous antinutritional factor, suggests to a chemist that it is ripe for the intelligent conversion to a high value-added feed or even a food crop, either by post-harvest acid treatment, to convert it to γ-glutamyl-L-cysteine and the volatile acetaldehyde, or alternatively, by replacing the gene for the S-ethenyl substituent of the narbon stench factor, (Figure 1A) with the corresponding biosynthetic gene for the aroma precursor present in the seeds of the chives plant (*Allium schoenoprasum* L.), which has a closely similar structure (Figure 1B). The only difference between the stench precursor and the aroma precursor is that the terminal hydrogen atom is replaced by a methyl-substituent. Ideally, a genetic modification should aim at converting GEC into a nutraceutical for the delivery of cysteine and not just a more tolerable flavour, since the palatability of high concentrations of the chives flavour precursor, would not necessarily be acceptable to consumers.

Using the knowledge about GEC in Australia, the available germplasm was screened to find genotypes with lower seed levels of this compound (5). Field trials with promising genotypes showed that soil sulphur levels can have a dramatic influence on seed levels of GEC and that not all the sulphur correlated with GEC (3), presumably due to premature ripening and accumulation of sulphate. A cultivar, Tanami, with somewhat reduced GEC levels was released and is now finding its niche in the Salmon Gums area of Western Australia.

What needs to be done now?

The high concentrations, of the S-substituted-cysteine in the seeds of narbon beans are both an obstacle and an opportunity. One approach is to get rid of GEC through selection. The other is to modify the biosynthetic pathway to enhance the nutritional value of the sulphur pool stored in GEC. A transformation protocol developed for the species by Thomas Pickardt (FU, Berlin) is available. Now, the tissues and sub-cellular compartments where GEC and its precursors are made need to be identified and the enzymes examined in detail. Dimitri Demidov (IPK, Gatersleben), Sabine Gillandt and Martin Meixner (FU, Berlin) have made some progress in locating tissues other than seeds where GEC can be detected in the plant.

For any successful plant-breeding programme it is essential, that a suitably fast and accurate non-extractive analysis be developed. Diffuse reflectance near infrared (NIR) is ideally suited for plant breeding purposes, and a suitable extractive analytical procedure for cross validating an NIR calibration curve has recently been published (1). Once this NIR analytical facility is widely available, it is predictable that a marketable narbon bean feed stuff could be developed from diversity generated through hybridisation or mutation. Careful control of soil sulphur levels during the selection progress will be essential.

Alternatively, development of a cheap post-harvest hydrolysis method to take advantage of the extremely high levels of GEC found in some accessions, could produce a valuable high cysteine feed stuff, thereby remedying the continual problem of the low sulphur amino acid content in most grain legumes.

It is important to evaluate whether the well-recognised ability of the sulphur atom to prevent free radical damage by sequestering oxygen free radicals, as exemplified by the use of thiourea to assist the germination of old seeds, is also correlated with the narbon bean's high GEC content and tolerance to both abiotic and biotic stresses. With the development of narbon bean varieties, that are both rich and poor in their GEC content, the opportunity arises to examine whether there is a positive correlation between a plant's GEC content and its ability to tolerate abiotic and biotic oxidative stresses. Such a discovery would provide a major step forward for agriculture.

Thus the much maligned and ill-regarded narbon bean could then be seen in a more positive light, as a gene reservoir for GEC-related traits, which might confer adaptability to a wide range of environments and as a model for crop improvement in general. ■

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Vetch production in Turkey

La production de vesces en Turquie

by Huseyin Kansur Fırıncıoğlu*

Livestock production in Turkey puts high grazing pressure on natural pastures and is limited by the quality of its rangelands. Principally, the rehabilitation of these grazing resources is designed to foster roughage production, and the introduction of forage species into crop rotations is to ameliorate feed resources. However, with the large livestock population and the reliance on natural pasture production, range rehabilitation is almost impractical, and therefore improving forage cultivation in cropping systems is crucial. To increase feed legume production, the introduction of forage crops into cereal and industrial crop (cotton, sugar beet, sunflower) rotations is essential. The major cultivated feed legumes, are common vetch (*Vicia sativa*), Hungarian vetch (*V. pannonica*), bitter vetch (*V. ervilia*), field pea (*Pisum sativum* ssp. *arvense*) and grass pea (*Lathyrus sativus*). Potentially important ones are hairy vetch (*V. villosa* ssp. *dasycarpa*) and narbon bean (*V. narbonensis*).

Vetch crops can also be grown alone as pure stands either for grain and straw, or for hay production in mixtures with crop species such as barley, oats and rye.

(Photo CRIFC, Turkey)

Variety yield trials of some annual forage legumes (grass pea and vetches) at CRIFC Research Station near Ankara.

Moreover, they can be grazed alone as short-term pastures. It is this versatility, which has led to an expansion in vetch production without any decline in the area of the main crops through appropriate short-term crop rotations.

In rainfed inland regions

In Turkish dryland farming systems, the cereal–fallow cropping pattern is still widely practised. In Central Anatolia, in place of the fallow, Hungarian vetch is now grown as a winter crop, and common vetch is used as a summer crop. When grown in a mixture with cereals they produce good quality hay. Various experiments conducted in the Ankara and Çorum Provinces of the Central Anatolian Region revealed that annual forage legumes can be grown successfully either alone or in mixtures with a companion cereal crop (17, 18). In Eskisehir Province, annual forage legumes, grown for herbage, did not cause any yield losses of the following wheat (10, 12). However, for seed production, some losses in subsequent cereal grain yield were attributed to a lower accumulation of nitrogen in the soil and to reduced amounts of water in the soil profile (10, 12).

In humid and sub-humid coastal regions

The beneficial effects of forages in rotations have been established unequivocally for both moist areas and under irrigation. In coastal areas, vetch forages can be used advantageously as a second crop in rotations in (a) winter from November to April, and (b) summer from May to October. In the humid coastal areas, wheat, barley, oats and rye are the main winter crops and maize, sunflower, tobacco, soyabean, sugarbeet, cotton and potato are the main summer crops. If the cereals are grown as the main winter crop, then after their harvest, silage maize or sorghum for hay can be grown during summer. In the Black Sea Region after the winter barley harvest the silage maize yields 6,850 kg/ha drymatter (1). In the traditional cotton–cotton rotation the field is empty for a period of five to six months from November to April; so during that period of time short-lived annual forage vetch crops can be grown beneficially. In Adana Province of southern Turkey, the introduction of various leguminous forage species into rotations improved the subsequent cotton yield significantly (6).

In the Çukurova Basin, common vetch and field pea in a mixture with cereals (especially with triticale) can be grown as winter crops for hay production (Personal communication with Dr Celal Yücel). Similarly in the Aegean Region, where the cropping pattern is cotton–cotton or wheat–cotton, the winter crop can be pure vetch or vetch in a mixture with a companion cereal, which produces 5–7 tonnes/ha dry matter yield (Personal communication with Dr Huseyin Ozpinar).

Common vetch is the most widespread

Over the last three years, just as in the European Common market, the government has started to subsidise vetch crops to encourage their production. Common vetch is one of the most widely cultivated annual forage crops in Turkey. It can be grown almost everywhere in Turkey, but generally is sown in the coastal regions in autumn for hay, whereas in Central and Eastern Anatolia it is produced for seed and straw. Fırıncıoğlu *et al.* (9) reported that in the Central Anatolian region, three-year average seed and straw yields of common vetch were 770 kg/ha and 1,270 kg/ha, respectively. In the coastal areas or on irrigated lands, 5.0–7.5 t/ha of dried

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herbage can be produced (7, 11, 13). Table 1 shows the recent increase in the area sown to the major vetches from 1985 to 2004.

Cold tolerant and winter hardy vetches

Hungarian vetch, as a winter feed legume, is the most cold tolerant and winter hardy of the annual forage legumes and is highly recommended for fallow replacement as a pure stand or in a mixture with cereals, preferably barley for hay production. It was first introduced to Turkey in the early 1980s within the framework of the Corum-Çankırı Rural Development Project. It is an especially promising crop for the Central and Eastern Anatolian Regions. Over the last five years its cultivation area seems to have increased. Under dryland conditions, the average grain and dry matter yields were 700 kg/ha and 2500 kg/ha, respectively. In rainfed areas and in a mixture with barley, up to 3–4 t dried herbage /ha can be obtained.

Because of its cold and drought tolerance, Narbon vetch can be grown successfully as a winter crop in the Central Highlands of Turkey. It is best grown for seed and straw yields in dry areas. It produces an impressive grain yield of 2.0–2.5 t/ha.

Bitter vetch has declined, but hairy vetches have potential

Table 1 shows that over the last 20 years, the area of bitter vetch has reduced dramatically to just a few thousand hectares. Formerly it was used to feed oxen, but mechanisation has diminished this use substantially. Herbage and seed yields varied from 1 to 2 t/ha and from 800 to 1,000 kg/ha, respectively (3, 4). Some lines of bitter vetch grown as winter crops produced up to 7,500 kg herbage/ha and 2,500 kg seed/ha (8, 19). Three-year average seed and straw yields of bitter vetch were 800 and 1,010 kg/ha respectively in Central Anatolia (9).

(Photo CRIFC, Ankara, Turkey)

Pre-basic seed production of Hungarian vetch (*V. pannonica* variety Tarmbeyazi-98) at CRIFC Research Station, near Ankara, Turkey.

Hairy vetch (*V. villosa* ssp. *villosa*) is a potentially important crop, which can be used as hay, pasture, green manure or cover crop. It is quite cold tolerant, and is planted in autumn and cut for hay in mid June. It can be grown as a pure stand or in a mixture with barley. The pure stand produced 2,000–2,500 kg hay/ha, while the mixture with cereals produced 4,000–5000 kg hay/ha (2). The seed yield varies from 400 to 1,000 kg/ha (5, 16).

Hairy-pod vetch (*V. villosa* ssp. *dasycarpa*) yields slightly less, but it matures about two weeks earlier than hairy vetch. It is reasonably cold and drought tolerant. Because of its earliness, it can be incorporated easily into cropping systems.

Thus in Turkey, both the implementation by farmers and the ongoing research studies indicate clearly that the use of appropriate, intervening short-term, summer or winter legume rotations, can result in a substantial increase in overall crop production. ■

	Common vetch		Bitter vetch	
	Area sown (ha)	Production (tonnes)	Area sown (ha)	Production (tonnes)
1985	212,000	169,000	18,000	19,000
1990	259,000	175,000	11,000	11,000
1995	270,000	160,000	9,200	7,300
2000	225,300	134,000	3,550	3,600
2001	240,000	127,000	2,900	3,000
2002	234,227	129,124	2,850	3,000
2003	250,000	121,000	3,000	2,300
2004	320,000	130,000	3,200	2,500

Source: SSI (15)

Table 1. The sown area (ha) and grain production (tonnes) of major vetches in Turkey in the last 20 years.

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