Biotechnology in Animal Husbandry 23 (5-6), p 573 - 581 , 2007 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 633.31

POTENTIAL OF ANNUAL LEGUMES FOR UTILISATION IN ANIMAL FEEDING**

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**Plenary invited paper

Abstract: Pea and common vetch have been successfully grown for green forage and forage dry matter production, with yields higher than 30 t ha^{-1} of green forage and 7 t ha^{-1} of forage dry matter. Pea and faba bean have the greatest potential as feed annual legumes, with more than 5,000 kg ha^{-1} and harvest indexes of nearly 0.50. When cut in the stages of full flowering and first pods forming, the average crude protein content of forage dry matter in most annual legumes ranges about 200 g kg^{-1}. Although most modern cultivars of pea contain between 250 and 270 g kg^{-1} of crude proteins of grain dry matter, they are characterised by a rather low content of anti-nutritive factors. Forage dry matter of annual legumes may be regarded as rich in lysine, with 13.9 g kg^{-1} in hairy vetch and 12.7 g kg^{-1} in common vetch. It is notable that Narbonne vetch (*Vicia narbonensis* L.) is rather rich in lysine, with average values of more than 20 g kg^{--1}, closely followed by grass pea, with average values of nearly 20 g kg^{--1}. Common vetch, Narbonne vetch and pea have higher content of methionine in comparison to other annual legumes such as grass pea and lentil.

Key words: annual legumes, forage, grain, yield, crude protein content. amino acid content.

Importance, origin and distribution of annual legumes

On a world scale, the most important annual legume is soya bean (*Glycine max* (L.) Merr.), while *Phaseolus* beans represent the most widely distributed pulses. Among other annual legume species, the most significant are pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.), lupins (*Lupinus* spp.), lentil (*Lens culinaris* Medik.), chickpea (*Cicer arietinum* L.), cowpea (*Vigna unguiculata* (L.) Walp.), pigeon pea (*Cajanus cajan* (L.) Millsp.) and

vetches (*Vicia* spp.).

Annual legumes are utilised in the form of green forage, forage dry matter, forage meal, grain, straw, silage, haylage, while some of them are suitable for grazing as well (Mihailović *et al*., 2007c). These species represent excellent sources of green manure in the modern trends such as sustainable agriculture and organic farming (Ćupina *et al.*, 2004).

It is the Near Eastern and Mediterranean centres that are the primary centres of the majority of annual legume species, including chickpea, grass pea (*Lathyrus odoratus* L.) and other vetchlings (*Lathyrus* spp.), lentil, lupins, pea and vetches, while pigeon pea, hyacinth bean (*Lablab purpureus* Sweet) and cowpea originate form the African centre and faba bean from the Central Asian centre of diversity (Zeven & Zhukovsky, 1975).

Apart from soya bean and *Phaseolus* beans, the annual legumes with the greatest harvest area are chickpea and cowpea, with more than 10,000,000 ha on a world scale (Table 1). Despite a considerable potential, low grain yields remain one of the long-term problems in annual legumes cultivation today. Pea in Serbia is grown on 40,000 ha, with protein pea on 22,000 ha, forage pea on 4,000 ha and garden pea on 14,000 ha, while common vetch (*Vicia sativa* L.), Hungarian vetch (*Vicia pannonica* Crantz) and hairy vetch (*Vicia villosa* Roth) are cultivated on about 7,500 ha (Mihailović *et al.*, 2005a) There are no official data neither on harvested area nor on production of the species such as faba bean or lentil.

Table 1. Harvested area and production per year in annual legumes on a world scale (FAOSTAT, 2007)

Species	Harvested area (ha)	Production (t)
Chickpea	10,943,016	8,596,990
Cowpea	10,730,608	3,836,799
Faba bean	2,587,855	4,276,425
Lentil	3,957,956	3,753,371
Lupins	964,986	1,126,590
Pea	6,327,132	12,204,186
Pigeon pea	4,611,749	3,306,003
Vetches	891,571	1,252,939

Forage and grain yields in annual legumes

Pea and common vetch have been successfully grown for green forage and forage dry matter production for centuries in many regions with

temperate climate, with yields higher than 30 t ha^{-1} of green forage and 7 t ha^{-1} of forage dry matter in most years. Among the traditional Serbian annual legumes, it is faba bean that can produce more than 40 t ha^{-1} of green forage and more than 10 t ha^{-1} of forage dry matter, while hairy vetch is of similar performance to pea or common vetch (Table 2). With yields of more than 25 t ha^{-1} of green forage and about 8 t ha^{-1} of forage dry matter in the conditions of Serbia, sub-tropical species such as cowpea and pigeon pea can provide animal husbandry with quality forage during summer.

Table 2. Forage yields in annual legumes (*Mihailović et al.*, 2005b; *Mihailović et al.*, 2005c; *Mikić et al.*, 2005; *Mihailović et al.*, 2006a; *Mihailović et al.*, 2006d; *Mihailović et al.*, 2007b)

Species	Green forage yield (t ha^{-1})	Forage dry matter yield (t ha^{-1})
Bitter vetch	30.7	6.9
Common vetch	31.8	7.0
Cowpea	27.2	7.6
Faba bean	42.5	10.5
Hairy vetch	31.2	5.7
Hungarian vetch	24.2	5.3
Lentil	25.6	6.1
Narbonne vetch	16.3	4.8
Pea	34.9	7.1
Pigeon pea	28.7	8.1

Pea and faba bean have the greatest potential as feed annual legumes, with more than 5,000 kg ha^{-1} and harvest indexes of nearly 0.50 (Table 3).

Table 3. Grain yield in annual legumes (*Mihailović et al.*, 2005d; *Mihailović et al.*, 2006b; *Mihailović et al.*, 2006c; *Mikić et al.*, 2006b; *Mihailović et al.*, 2007a)

Species	Grain yield (kg ha^{-1})	Harvest index
Bitter vetch	1320	0.38
Common vetch	2818	0.35
Cowpea	1703	0.22
Faba bean	5369	0.47
Grass pea	3324	0.35
Lentil	1350	0.34
Narbonne vetch	2730	0.44
Pea	5518	0.50
Pigeon pea	1365	0.19
White lupin	2189	0.48

Thanks to recent achievements in breeding, newly developed cultivars of common vetch can produce more than 2,500 kg ha^{-1}. Grass pea represents the most promising of the neglected and nearly forgotten grain legumes in Serbia.

Protein content in annual legumes

When cut in the stages of full flowering and first pods forming, the average crude protein content of forage dry matter in most annual legumes ranges about 200 g kg^{-1}. Most often, the lowest values are found in pea and faba bean, while the highest values are found in vetches (Table 4).

Table 4. Crude protein content of forage dry matter in annual legumes (*Mihailović et al.*, 2006e*; Mikić et al.*, 2006a)

Species	Crude protein content (g kg^{-1})
Common vetch	203
Faba bean	189
Hairy vetch	215
Hungarian vetch	218
Pea	179
Soya bean	189

As compared to soya bean, other annual legumes are less rich in crude protein of grain dry matter (Table 5). Although most modern cultivars of pea contain between 250 and 270 g kg^{-1} of crude proteins of grain dry matter, they are characterised by a rather low content of anti-nutritive factors, making themselves suitable for direct utilization in animal feeding without heat treatments. If combined with low content of vicine and other poisonous matters, common vetch grain may represent a rich protein source.

Table 5. Crude protein content of grain dry matter in annual legumes (*Hadjipanayiotou & Economides*, 2001; *Milczak et al.*, 2001; *Mikić et al.*, 2003)

Species	Crude protein content (g kg^{-1})
Common vetch	313
Faba bean	274
Grass pea	290
Lentil	291
Narbonne vetch	269
Pea	267
Soya bean	533

Amino acid content in annual legumes

Forage dry matter of annual legumes may be regarded as rich in lysine, with 13.9 g kg^{-1} in hairy vetch and 12.7 g kg^{-1} in common vetch (Table 6). These two species also have higher lysine content in comparison to pea and soya bean.

Table 6. Amino acid content of forage dry matter (g kg^{-1}) in annual legumes (Prokof'eva, 1985)

Species / Amio acid	Common vetch	Hairy vetch	Pea	Soya bean
Arginine	11.6	13.4	12.1	10.8
Histidine	6.6	5.9	4.7	4.0
Isoleucine	9.4	8.5	8.5	8.0
Leucine	14.1	15.4	12.3	13.7
Lysine	12.7	13.9	10.1	11.2
Methionine	1.7	1.3	1.0	1.2
Threonine	7.6	9.5	6.3	8.0
Valine	14.1	12.1	9.7	11.3

Table 7. Amino acid content of grain dry matter (g kg^{-1}) in annual legumes (*Hadjipanayiotou & Economides,* 2001; *Milczak et al.*, 2001)

Species / Amino acid	Common vetch	Faba bean	Grass pea	Lentil	Narbonne vetch	Pea	Soya bean
Alanine	4.4	3.3	13.5	10.2	5.6	4.4	30.2
Arginine	6.6	13.2	22.4	19.0	9.0	16.7	40.2
Aspartic acid	25.4	33.1	34.5	29.6	28.0	32.2	76.0
Cystine	4.5		5.0	2.7			
Glutamic acid	22.1	28.7	49.8	42.7	33.6	17.8	35.8
Glycine	9.9	11.0			12.3	13.3	23.5
Histidine	16.6	7.7	8.4	6.2	19.0	10.0	12.3
Isoleucine	14.3	11.0	10.8	9.4	17.9	13.3	29.1
Leucine	21.0	18.7	18.3	17.4	24.6	17.7	44.7
Lysine	16.6	16.5	19.4	17.4	22.4	13.3	36.9
Methionine	4.4	3.3	2.5	2.0	4.5	4.4	7.8
Phenylalanine	14.3	14.3	12.1	13.2	17.9	16.7	31.3
Proline	4.4	4.4			7.8	6.7	8.9
Serine	19.9	28.7	13.7	12.6	20.2	31.1	64.8
Threonine	12.1	7.7	11.1	9.6	13.4	6.7	17.9
Tryptophan	2.4		2.1	1.6			
Tyrosine	9.9	8.8	8.1	7.6	10.1	8.9	20.1
Valine	22.1	15.4	12.4	12.5	19.0	18.9	33.5

Thanks to a higher crude protein content of grain dry matter, soya bean is characterised by a higher content of nearly all essential amino acids in comparison to other annual legume species (Table 7). It is notable that Narbonne vetch (*Vicia narbonensis* L.) is rather rich in lysine, with average values of more than 20 g kg^{--1}, closely followed by grass pea, with average values of nearly 20 g kg^{--1}. Common vetch, Narbonne vetch and pea have higher content of methionine in comparison to other annual legumes such as grass pea and lentil. Common vetch and grass pea are also richer in tryptophan than lentil.

Conclusion

Due to a rather great diversity of species and a wide variability of the characteristics of agronomic importance, annual legumes represent important crops for diverse environments, suitable for utilisation in many ways and for numerous purposes. High protein content in their forage and grain, together with a balanced content of majority of the essential amino acids, establishes them as crops with a great potential for answering the constant demand for plant protein in animal husbandry.

POTENCIJAL ZA KORIŠĆENJE JEDNOGODIŠNJIH LEGUMINOZA U ISHRANI ŽIVOTINJA

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Rezime

Grašak i grahorica se uspešno gaje u proizvodnji kao zelenog krmova i suve materije krmiva, i ostvaruju prinose veće od 30 t ha^{-1} zelenog krmiva i 7 t ha^{-1} suve materije krmiva. Gršak i bob imaju najveći potencijal kao stočne jednogidišnje leguminoze, sa više od 5,000 kg ha^{-1} I indeks žetve od približno 0.50. Ako se kosi u stadijumu punog cvetanja i formiranja prvih mahuna, prosečan sadržaj sirovog proteina u suvoj materiji krmiva kod većine jednogodišnjih leguminoza je oko 200 g kg^{-1}. Iako većina savremenih sorti graška sadrži između 250 i 270 g kg^{-1} sirovih proteina u suvoj materiji

zrna, karakteriše ih dosta nizak sadržaj anti-nutritivnih faktora. Suva materija jednogodišnjih leguminoza se smatra bogatom lizinom, sa 13.9 g kg^{-1} kod maljave grahorice i 12.7 g kg^{-1} kod grahorice. Narbonne grahorica (*Vicia narbonensis* L.) je takođe bogata lizinom, sa prosečnim vrednostima većim od 20 g kg^{--1}, zatim sastrica, sa prosečnim vrednostima od skoro 20 g kg^{--1}. Grahorica, Narbonne grahorica i grašak imaju veći sadržaj metionina u poređenju sa ostalim jednogodišnjim leguminozama kao što su sastrica i sočivo.

Ključne reči: jednogodišnje leguminoze, krmivo, zrno, prinos, sadržaj sirovog proteina, sadržaj amino kiselina.

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