Pigeon pea (Cajanus cajan) forage

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Common names

Pigeon pea, no-eye pea, no-eyed pea, tropical green pea, cajan pea [English]; pois d'Angole, pois cajan, pois-congo, ambrevade [French]; guandú, gandul, guandul, frijol de palo, quinchoncho [Spanish]; guandu, andu, anduzeiro, guandeiro, feijão boer [Portuguese]; Straucherbse [German]; pwa kongo [Haitian creole]; gude, kacang gude [Indonesian]; caiano [Italian]; umukunde [Kinyarwanda]; pī kula [Tongan]; Đậu triều [Vietnamese]; 木豆 [Chinese]; [Gujarati]; [Hindi]; キマメ [Japanese]; نخود کفتری [Persian]; Голубиный горох [Russian]; [Tamil]

Species

Cajanus cajan (L.) Huth [Fabaceae]

Synonyms

Cajanus bicolor DC., *Cajanus flavus* DC., *Cajanus indicus* Spreng., *Cytisus cajan* L.

Feed categories

- Legume forages

Related feed(s)

- Pigeon pea (Cajanus cajan) seeds

Description

Pigeon pea (*Cajanus cajan* (L.) Huth) is one of the most common tropical and subtropical legumes cultivated for its edible seeds. Pigeon pea is fast growing, hardy, widely adaptable, and drought resistant (Bekele-Tessema, 2007). Thanks to drought resistance it can be considered of utmost importance for food security regions places where rain failures are prone to occur (Crop Trust, 2014). At the end of the dry season, pigeon pea provides green forage of oustanding value when other forages have disappeared (Sloan et al., 2009).

Morphology

Pigeon pea is an erect, short-lived perennial leguminous shrub generally about 1-2 m tall but sometimes up to 2-5 m high. It quickly develops a deep (2 m depth) poisonous taproot. The stems are woody at the base, angular, branching. The leaves are alternate, trifoliate. The leaflets are oblong, lanceolate, 5-10 cm long x 2-4 cm wide. Leaves and stems are pubescent. The flowers (5 to 10) are grouped in racemes at the apices or axils of the branches. The flowers are papillonaceous and generally yellow in colour. They can also be striated with purple streaks. The corolla is about 2-2.5 cm. The fruit is a flat, straight, pubescent, 5-9 cm long x 12-13 mm wide pod. It contains 2-9 seeds that are are brown, red or black in colour, small and sometimes hardcoated (FAO, 2016a; Bekele-Tessema, 2007).

Uses

Though mainly cultivated for its edible seeds, *Cajanus cajan* can be considered a multipurpose species. Pigeon pea stems are a good fuel source, valued for its fast growing habit though their energy value is half that of charcoal. Stems and branches of pigeon pea are also used for basketry. Among other uses of pigeon pea, some experiments have shown a potential as paper pulp source. Pigeon pea also provides several environmental services (alley cropping, windbreak, cover crop, shade plant and green manure (see **Environmental impact** below) (Cook et al., 2005).

Cajanus cajan has numerous uses in animal feeding. The leaves and pods are valuable and palatable protein-rich fodder. Leaves are sometimes used to replace alfalfa in ruminants diets where alfalfa cannot be grown. Seed processing by-products and sometimes the seeds themselves are used as livestock feed (Phatak et al., 1993). The seeds can be fed to poultry, and mixtures of pigeon pea with maize grain were successful in Hawaii. Bees actively feed on pigeon pea and produce a honey with a distinctive colour (greenish) in the comb (Orwa et al., 2009). Pigeon pea is also a good host for lac insect and silkworms (Cook et al., 2005). Plant breeders have created varieties adapted to drier conditions, more resistant to diseases and suited to different production systems and cropping cycles (Valenzuela, 2011). Since the 1990s there has been a great scope for selecting cultivars with not only higher grain yields but also higher forage yields and crude protein (Phatak et al., 1993).

Distribution

The origin of *Cajanus cajan* is either Northeastern Africa or India (Ecocrop, 2016; van der Maesen, 1989). Its cultivation dates back to at least 3000 years (Mallikarjuna et al., 2011; van der Maesen, 1989). It is now a pantropical and subtropical species

particularly suited for rainfed agriculture in semi-arid areas thanks to its deep taproot, heat tolerance and fast growing habit (Mallikarjuna et al., 2011). *Cajanus cajan* can be found in both hemispheres from 30°N to 30°S and from sea level to an altitude of 2000 m (3000 m in Venezuela) (Ecocrop, 2016). It is very heat-tolerant and grows better in places where temperatures range from 20° to 40°C and which are deprived of frost (FAO, 2016a). Though sensitive to frost, pigeon pea keeps growing at temperatures close to 0°C and tall plants can survive light frost. It does better where annual rainfall is above 625 mm but it is highly tolerant of dry periods and, where the soil is deep and well-structured, it still grows with as low as 250 to 375 mm rainfall. Pigeon pea can grow on a wide range of soils ranging from sands to heavy black clays, with variable pH. However, best pH range is within 5-7. It has low tolerance of soil salinity, but some cultivars were reported to tolerate high (6-12 dS/m) salinity (Duke, 1983). *Cajanus cajan* is sensitive to salt spray and waterlogging. Under shade, it shows reduced growth and bear thin, pale green foliage and few pods (FAO, 2016a).

World production of pigeon peas was 4.85 million t in 2014. The main producers were India (3.29 million t, 65% of world production), Myanmar (0.57 million t), Malawi (0.3 million t), Kenya (0.28 million t), Tanzania (0.25 million t). Most of the production occurred in Asia (79.1%), followed by Africa (17.6%) and the Americas (2.5%) (FAO, 2016b).

Forage management

Establishment

Pigeon pea can be grown for seed production, forage production or both. Some double purpose cultivars have been developed. Pigeon pea can be grown in pure stands or sown with Rhodes grass (*Chloris gayana*), *Cynodon dactylon* and molasses grass (*Melinis minutiflora*) in Hawaii, and with pangola grass (*Digitaria eriantha*) in Brazil (FAO, 2016a). Association with cereal grains such as maize, sorghum or millet is possible (Bekele-Tessema, 2007; Cook et al., 2005). Associations with other legumes are not recommended for fodder production (Cook et al., 2005). Seeds shoud be broadcasted or planted in rows with at least 20 kg/ha. Seeds should be sown (drilled, broadcasted or hand dibbled) in a weeded, deep and well prepared seedbed at 2.5 cm to 10 cm depth. For the later maturing of highly branched fodder varieties, recommended density is 50,000-60,000 plants/ha (Cook et al., 2005). Pigeon pea does not establish easily. It may require irrigation during the first 2 months if rainfall is insufficient. It is important to make effective weed control (Valenzuela, 2011; AFF, 2009; Duke, 1983). Pigeon pea has a very variable growing pattern. Depending on the cultivar, the location and time of sowing, flowering can occur as early as 100 days to as late as 430 days . In the West Indies, the range was within 60-237 days between planting and podding, time for flowering being only 60 days. In India, pigeon pea could require 8 months before flowering (Duke, 1983).

Grazing

Pigeon pea can be sown in pure stand or in mixed pastures. It had been previously reported that young plants were not palatable to livestock, but experiments have since shown that cattle relished young plants (Sloan et al., 2009; Cook et al., 2005). For this reason and because the plant is sensitive to heavy defoliation, it has been recommended to wait for full establishment (flowering stage) before grazing (Sloan et al., 2009). Once establishment is achieved, grazing should remain light and rotational. *Cajanus cajan* does not withstand heavy and continuous grazing. In Brazil, pigeon pea could be grazed for up to 5 years with careful management (FAO, 2016a). However, fodder production declines over the lifespan (Cook et al., 2005).

Yield

Forage yield ranges from 20-40 t DM/ha. Levels as high as 24 t DM/ha of fodder and stalks have been reported in Sahel, and it has been suggested to further study the use of pigeon pea as forage plant in this area (FAO, 2016a). Up to 40 tons DM/ha could be expected under optimal conditions (ILRI, 2013).

Environmental impact

Cover crop, soil improver and green manure

Pigeon pea is used as a contour hedge in erosion control (Bekele-Tessema, 2007). An N-fixing legume, it does not need inoculation before sowing. It was reported to fix 40-97 kg N/ha/year in Africa and up to 235 kg N/ha/year in Florida, 88% being used for pods and seeds formation. Pigeon pea cultivation would be able to provide 40-60 kg N/ha to the following crop (Valenzuela, 2011). Pigeon pea had a large residual effect on maize, increasing grain yield by 57% and total plant dry matter by 32% (Kumar Rao et al., 1983). The extensive root system of *Cajanus cajan* improves soil structure by breaking plow pans, and enhances water holding capacity of the soil (Crop Trust, 2014; Mallikarjuna et al., 2011). Its deep taproot is able to extract nutrients (like P) from the soil low layers, and bring them to upper layers where they can benefit to other crops (Valenzuela, 2011). The leaves and immature stems can be cut and used as a green manure (OAF, 2015). Fallen leaves act as a mulch and are estimated to return about 40 kg N/ha. They return organic matter, preventing erosion due to heavy rains, and reduce soil temperatures (Ecocrop, 2016).

Windbreak and shade provider

Tall varieties of pigeon pea are reported to be good windbreaks. Pigeon pea is able to provide shade to young coffee or vanilla plants, and to forest seedlings in nurseries (Valenzuela, 2011).

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Nutritional attributes

Pigeon pea foliage is a protein rich forage (10-27%). Young leaves contains above 20% DM protein while old leaves may contain less than 12% DM protein. However, a high proportion of the protein is bound in fibre (20-26% N bound in ADF) and thus less available for digestion (Pires et al., 2006; Veloso et al., 2006; Foster et al., 2011). Pigeon pea foliage has a quite high fibre content, particularly ADF 16-37% and lignin 7-21% DM.

Ruminants

Fresh forage and hay

Pigeon pea forage is a protein-rich forage, but its high fibre content (particularly ADF and lignin) decreases digestibility and limits its potential use. It can be considered as a medium to low energy quality forage.

Digestibility and degradability

DM or OM digestibility of fresh pigeon pea leaves and hay are within the range 50-60% (da Silva et al., 2009). *In vivo* DM or OM digestibility of pigeon pea hay was found to be close to that of cowpea hay (55-56%) but slightly lower to that of the other legume hays (annual or perennial peanut, soybean) (Foster et al., 2009a). Fed as haylage, pigeon pea seems clearly less digestible than the other warm-season legumes (Foster et al., 2009b).

Pigeon pea forage is characterized by low *in situ* ruminal DM, NDF and N disappearance kinetics when compared to other warm-season legumes or poor quality forage hays, with much lower potentially degradable fraction and much greater undegradable fraction (Carvalho et al., 2006; Pires et al., 2006; Veloso et al., 2006; Foster et al., 2011). This limits its potential use for high producing animals such as dairy cows.

Beef cattle

In the USA, yearling cattle intensively grazing pigeon pea in late-summer achieved an average daily weight gain close to 1.0 kg/d (Rao et al., 2012).

Sheep

In Nigeria, fresh cajan pea was found to be preferred by sheep among 8 browse species (Omokanye et al., 2001). In Zimbabwe, fresh pigeon pea included at 30% (DM) as a protein source to supplement a poor quality maize stover diet increased total voluntary DM intake by 20% and total diet OM digestibility from 52 to 61% a (Masama et al., 1997). In Thailand, voluntary DM intake was 2.5% of BW (58 g/kg $BW^{0.75}$) on a pigeon pea leaves based diet (Cheva-Isarakul, 1992). In Brazil, voluntary DM intake was 3.5% of BW (65 g/kg $BW^{0.75}$) on a pigeon pea hay based diet (da Silva et al., 2009). In the USA, when included at 50% (DM) in a Bahia grass (*Paspalum notatum*) hay or haylage based diet, pigeon pea as hay or haylage had a detrimental effect on DM intake when compared to other warm-season legumes (Foster et al., 2009a; Foster et al., 2009b).

Goats

Goats were found superior than sheep for using pigeon pea foliage (Devendra et al., 1980).

Crop residues

Voluntary DM intake of sheep fed on pods alone is very low (16 g/kg BW), in vivo DM digestibility being only 44%. Voluntary intake of pigeon pea crop residues by goats was 18% greater than that of sheep (26 vs. 22 g DM/kg BW), and similar to that of young cattle, with low in vivo DM digestibility (47-54%). In the three species, nutrients intake from pigeon pea crop residues fed alone was not sufficient to maintain weight (Whiteman et al., 1980).

Pigs

Several experiments on using pigeon pea as a forage protein source for growing and fattening pigs have been done since the 2010s in Cuba, Venezuela and Spain. Pigeon pea could be fed to up to 24% to creola pigs without health problems. However, pigs had increased ileal and rectal flow of both DM and water, which indicates lower digestibility of diets containing pigeon pea forage (Diaz et al., 2007). Growth performance decreased at levels as low as 6% in creole pigs diets, back thickness increased as pigeon pea forage increased, and economic performance decreased while increasing pigeon pea forage (Estupiñán et al., 2013; Estupiñán, 2013).

Poultry

In Nigeria, pigeon pea leaf meal tested in layers maintained laying performance up to 7.5% but feed efficiency decreased due to an increase in feed intake. Egg yolk color score was increased by pigeon pea leaf meal in the diet (Udedibie et al., 1989). An early study in the USA found dry pigeon pea leaves to be a useful replacement for alfalfa as a source of carotene and other essential nutrients in chicken rations (Squibb et al., 1950).

Rabbits

Green forage

Green leaves and small branches of pigeon pea are used as protein rich forage in familial rabbitries in West and East African countries such as Uganda (Lukefahr, 1998; Djago et al., 2010). Pigeon pea forage distributed in addition to a concentrate to breeding does reduced fertility and litter size when compared to other forages such as *Moringa oleifera* and *Tephrosia candida* (Ola et al., 2012). This may be due to the very low content of pigeon pea forage in P: 0.15 to 0.17% DM *vs.* 0.30-0.35% DM for the two more suitable forages (Lebas et al., 2013). This alteration of reproductive performance may be also related to the increase of serum progesterone level as observed in pregnant rats receiving aqueous extract of *Cajanus cajan* leaves (Olayaki et al., 2009). While the increase in serum progesterone level during pregnancy has favourable consequences on female reproduction, its effect is negative before mating as demonstrated in hyperprogesteronemic rabbit does (Boiti et al., 2006). As a consequence, it can be recommended to discard pigeon pea forage from rabbit does feeding during the 8-10 days preceding a programmed mating and until confirmation of pregnancy. Afterwards it could safely represent up to 25-30% of the DM intake.

Pigeon pea hay and leaf meal

Cajanus cajan hay was found to have a very low digestibilities for DM, protein and crude fibre (24%, 26% and 27% respectively), resulting in a very low nutritive value (Ferreira et al., 1997). However, its incorporation in the diet as replacement of *Cynodon dactylon* hay led to non-significantly better performance of growing rabbits: daily gain 32.3 *vs.* 30.7 g/d (Moura et al., 1992). In growing rabbit diets, 15% of pigeon pea leaf meal substituting for 15% maize offal induced identical growth and slaughter performance (Togun et al., 2008). *Cajanus cajan* hay could even completely replace alfalfa hay (37%) in the diet of growing rabbits without any alteration of growth or slaughter performance. Only the feed efficiency was impaired with 100% replacement when compared with 0, 25, 50 or 75% replacement (Crespi et al., 1992). The replacement of 25% of commercial feed in growing rabbits feeding led to growth and slaughter performance similar to that of the control (100% commercial feed). When more than 25% of the commercial feed were replaced by pigeon pea hays performances were significantly impaired (Gonzalez et al., 1990).

It can therefore be concluded that *Cajanus cajan* hay or leaf meal can be used safely in rabbit feeding as a source of protein and fibre, and that it can represent up to 30-35% of balanced diets. However, the above recommendations about the use of green forage for breeding does should be applied to the hay. When formulating balanced diets, the low proportion of sulphur-containing amino acids of pigeon pea protein and the very low level of phosphorus must be taken into account.

Horses and donkeys

Pigeon pea forage does not seem useful for horse diets due to its very low *in situ* caecal degradation, compared to other roughages (Silva et al., 2010).

Crustaceans

Pod husks

Pod husks of *Cajanus cajan* offer excellent alternatives to rice bran as a diet source for *Artemia* sp. in terms of survival, growth, fecundity, and naupliar production (Yoganandhan et al., 2000).

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Tables of chemical composition and nutritional value

- Pigeon pea (Cajanus cajan), aerial part, fresh
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- Pigeon pea (Cajanus cajan), pods

Avg: average or predicted value; SD: standard deviation; Min: minimum value; Max: maximum value; Nb: number of values (samples) used

Pigeon pea (Cajanus cajan), aerial part, fresh

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	31.8	7.6	24.4	49.7	15
Crude protein	% DM	19.0	4.7	10.1	26.7	33
Crude fibre	% DM	30.6	6.5	21.3	45.1	21
NDF	% DM	47.5	8.4	37.2	62.9	11
ADF	% DM	30.5	6.7	15.7	38.7	11
Lignin	% DM	15.1	3.6	7.3	21.4	12
Ether extract	% DM	4.3	1.1	2.4	6.1	16
Ash	% DM	6.1	1.0	4.0	8.8	31
Gross energy	MJ/kg DM	19.7		19.7	24.5	2 *

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	7.2	1.7	4.6	10.8	19
Phosphorus	g/kg DM	1.8	0.5	1.0	2.6	15
Potassium	g/kg DM	14.7	4.1	9.1	20.8	12
Sodium	g/kg DM	0.3		0.2	0.3	2
Magnesium	g/kg DM	2.4	1.2	1.5	5.5	13
Manganese	mg/kg DM	74		73	75	2
Zinc	mg/kg DM	39		23	54	2
Copper	mg/kg DM	10		7	12	2
Iron	mg/kg DM	213		181	244	2

Amino acids	Unit	Avg	SD	Min	Max	Nb
Arginine	% protein	5.7				1
Histidine	% protein	2.7				1
Isoleucine	% protein	3.8				1
Leucine	% protein	6.6				1
Lysine	% protein	2.2				1
Phenylalanine	% protein	4.2				1
Threonine	% protein	5.8				1
Valine	% protein	5.2				1

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	28.0				1

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, ruminants	%	64.6				*
OM digestibility, ruminants (gas production)	%	69				1
Energy digestibility, ruminants	%	61.7				*
DE ruminants	MJ/kg DM	12.1				*
ME ruminants	MJ/kg DM	9.6				*
ME ruminants (gas production)	MJ/kg DM	10.2				1
Nitrogen digestibility, ruminants	%	64.5		60.0	69.0	2
a (N)	%	30.8				1
b (N)	%	58.6				1

c (N)	h-1	0.120	1
Nitrogen degradability (effective, k=4%)	%	75	*
Nitrogen degradability (effective, k=6%)	%	70	*

The asterisk * indicates that the average value was obtained by an equation.

References

Adjolohoun, 2008; Ahmed et al., 2003; Ajayi et al., 2009; Axtmayer et al., 1938; Barnes, 1998; CIRAD, 1991; FUSAGx/CRAW, 2009; Kambashi et al., 2014; Krauss, 1921; Meale et al., 2012; Mecha et al., 1980; Omokanye et al., 2001; Padilla et al., 2002; Pires et al., 2006; Silva et al., 2010; Work, 1937

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Pigeon pea (Cajanus cajan), hay

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	90.3		88.8	91.8	2
Crude protein	% DM	14.5		12.2	16.7	2
Crude fibre	% DM	32.5				1
NDF	% DM	78.6				1
ADF	% DM	60.2				1
Lignin	% DM	17.1				1
Ether extract	% DM	1.9				1
Ash	% DM	4.6		3.9	5.3	2
Gross energy	MJ/kg DM	19.2				*

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins, condensed (eq. catechin)	g/kg DM	11.3				1

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, Ruminant	%	59.7				*
Energy digestibility, ruminants	%	56.3				*
DE ruminants	MJ/kg DM	10.8				*
ME ruminants	MJ/kg DM	8.7				*

The asterisk * indicates that the average value was obtained by an equation.

References

Foster et al., 2009; Krauss, 1921

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Pigeon pea (Cajanus cajan), pod husks

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	93.0				1
Crude protein	% DM	6.7				1
Crude fibre	% DM	38.0				1
Ether extract	% DM	0.3				1
Ash	% DM	5.0		4.1	5.8	2
Gross energy	MJ/kg DM	18.4				*

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	9.7		8.4	11.0	2
Phosphorus	g/kg DM	1.8		0.9	2.7	2
Magnesium	g/kg DM	3.0				1
Zinc	mg/kg DM	33				1
Copper	mg/kg DM	13				1
Iron	mg/kg DM	744				1

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, Ruminant	%	82.0				*

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	30.4				*

DE growing pig	MJ/kg DM	5.6	*

The asterisk * indicates that the average value was obtained by an equation.

References

Devendra et al., 1970; Gowda et al., 2004

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Pigeon pea (Cajanus cajan), pods

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	87.3				1
Crude protein	% DM	20.3				1
Crude fibre	% DM	35.2				1
Ether extract	% DM	1.7				1
Ash	% DM	3.3				1
Gross energy	MJ/kg DM	19.7				*

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, Ruminant	%	82.9				*

Pig nutritive values	Unit	Avg	SD	Min	Max	Nb
Energy digestibility, growing pig	%	34.8				*
DE growing pig	MJ/kg DM	6.9				*

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References

Krauss, 1921

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Pigeon pea (Cajanus cajan) forage

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