A review of the potential of *Imperata cylindrica* (L.) raeusch as feed for ruminant animals

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The shortage of feed, particularly during the dry season is one of the major factors limiting the productivity of livestock in the tropics. *Imperata* is a natural grass of which control is very difficult, but shows the potential to alleviate the problem because it is drought resistant and has a high nutritive value when it is young. An attempt to generate useful information for improving the utilization of this grass, its potential and limitations were described. Its chemical composition and nutritive value related to management and animal requirements were reviewed. Possible solutions were also discussed to increase animal production from this low quality Imperata grass.

Keywords: *Imperata cylindrica*, potential, limitation, animal production

*Imperata cylindrica* (L.) Raeusch (hereafter is called *Imperata*), commonly known as alang-alang, lalang, cogon grass, blady grass and many other names, is native to southeast Asia (McDonald et al. 2016) and now has been naturalized in Americas, Northern Asia, Europe, Africa and Australia. In Asia, the area of *Imperata* grassland is about 35 million ha; this is about 4% of the total land area. The countries with the largest area of *Imperata* grassland are Indonesia (8.5 million ha) and India (8 million ha) and it occupies both fertile and infertile soils (Garrity et al. 1977). In Indonesia, the large areas of *Imperata* grasslands, either being a dominant or minor component are found in Sumatera, Kalimantan and Sulawesi. *Imperata* invades not only grazing land, but also cultivated lands, deforested areas and plantations of various crops.

*Imperata* generally invades grazing lands where slash and burn agricultures is widely practiced (Falvey 1981). Fires stimulate flowering and regrowth of *Imperata*’s rhizomes. The underground rhizomes are fire-resistant and if fires are frequent, this plant will gradually become more dominant. However, when *Imperata* grasslands are abandoned and not burned regularly, they will undergo a series of vegetation changes (Yassir et al. 2010).

*Imperata* is a very competitive plant that brings about serious problems when growing under plantation and with agricultural crops. Holm (1969) listed *Imperata* as one of the ten worst weeds in the world. Because of its aggressiveness and low quality, it is most commonly recognized as weed rather than useful species, and due to this reason, the main emphasis of research has been its control or eradication (Falvey 1981).

The control of *Imperata* has been the subject of research in many countries. Digging out rhizomes and roots is the most effective way but it is laborious and only effective in small areas. Shading seems to be less effective in the short term (Lojka et al. 2011). Herbicide application, although effective and practicable, is very costly and needs repeated dressing to achieve eradication. Inefficient translocation of herbicide from the upper to underground parts of the plant may be the reason for the poor control of *Imperata* by herbicide application (Moosavi-nia and Dore 1979). Technologies have been developed for combating *Imperata* but very few have been adopted by small scale farmers (Towson 1991).

Because of difficult control, there are many workers who recommended that this grass be used as animal feed. As animal feed, it has been subjected to little research. This plant is palatable and nutritious only when it is young.
In a review, Falvey (1981) quoted the results of some workers who reported the lower dry matter yield, crude protein content and digestibility of Imperata compared with improved grass species. With advancing research of Imperata as animal nutrition, it seems appropriate to review and discuss some of the latest findings related to the grass. The objective of this paper was to review the nutritional characteristics of Imperata and its potential as a feed to ruminant animals.

Description and Ecology

Imperata is a perennial, rhizomatous plant that varies greatly in appearance. The leaves appear light green, with older leaves becoming orange-brown in color. It grows in loose to compact bunches, each bunch containing several leaves arising from the central area along a rhizome. The leaves originate directly from ground level and grow from one to four feet in length. The leaf margins are finely serrated, contributing to the undesirable forage qualities (McDonald et al. 2016). The flowers are grouped into large panicles, about 10 – 20 cm long. Each tiny flower has a fuzzy, plume like structure which can float the seed through the air (Coile et al. 1993).

Propagation of Imperata is by seed and rhizomes. The flowering is usually initiated by stress, such as burning, cutting or drought. Numerous seeds are produced (as many as 3000 seeds per plant) and germinate within a week of harvest and can remain viable for at least one year (Santiago 1965). Vegetative spread is aided by its tough and massive rhizomes that may remain dormant for a long period of time before sprouting. Vegetative spread of rhizomes makes this plant one of the most aggressive and invasive weeds in the world.

Imperata can grow on soils with a wide range of nutrients, moisture and pH. Although sometimes known to be a weed for poor soils, it probably dominates these areas due to lack of competition from other species that cannot survive on marginal land (Santoso et al. 1997).

Dry matter yield

Dry matter yield of Imperata was comparable with many other natural tropical grasses, such as Axonopus compressus (Sw.) P. Beauv (L.) Pers. Panicum repens L., Cynodon dactylon L. and Cyperus rotundus L. (Kabir et al. 2002). Falvey (1981) reported that the mean annual dry matter production was 4,192 kg/ha of a 5-year old sward of Imperata; this value was not too different from 6,829 kg/ha from an unfertilized plant as reported by Chadhokar (1977). This also was in agreement with McDonald et al. (2016) who reported that Imperata yields are relatively low and usually do not exceed 5 tons per acre. The dry matter yield was also less, compared to many improved tropical grasses. Bulo et al. (1994) compared the dry matter yield of some tropical grasses harvested at 56 days of regrowth and reported that dry matter yield of Imperata was less compared with improved tropical grasses such as Brachiaria decumbens, Panicum maximum and Setaria sphacelata. Although dry matter yield could attain 11.43 tons/ha by high N fertilized input (Chadhokar 1977), dry matter yield of Imperata was far below elephant grass (Pennisetum purpureum). Schumach that could attain 50 - 80 tons DM/year under the high fertilized input (Skerman and Riveros 1990).

Chemical composition and nutritive value

Crude protein

The crude protein contents of Imperata harvested at various cutting intervals and different growth stages are presented in Table 1. The range of protein content of Imperata varied from 4 to 11.58% with the mean around of 7%. The highest crude protein content was obtained when the grass was harvested at short interval and the lowest crude protein content obtained when harvested at the flowering stage. Like many other kinds of grass, the age of the plant at time of harvest was the important factor influencing crude protein
content (Table 1). The decrease in the crude protein content as the plant ages is mainly attributed to the dilution of crude protein by rapid accumulation of cell wall components at the advanced stage of growth (Humphreys 1991).

Table 1: Crude protein content of *Imperata cylindrica* at various cutting interval

<table>
<thead>
<tr>
<th>Crude protein (%)</th>
<th>Conditions</th>
<th>Country</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.81, 7.0, and 6.0</td>
<td>Cutting interval of 2, 4, 6 weeks, respectively</td>
<td>Papua New Guinea</td>
<td>Chodhokar, 1977</td>
</tr>
<tr>
<td>8.5 and 6.7</td>
<td>Cutting interval of 20 and 40 days</td>
<td></td>
<td>Van Soest, 1994</td>
</tr>
<tr>
<td>5.93 and 11.58</td>
<td>Cutting interval of 75 and 25 days, respectively</td>
<td>Japan</td>
<td>Rusdy et al. 1995</td>
</tr>
<tr>
<td>9.50</td>
<td>4 cuttings in 6 months</td>
<td>Bangladesh</td>
<td>Kabir et al. 2002</td>
</tr>
<tr>
<td>4.23</td>
<td>Harvested at heading stage</td>
<td>Indonesia</td>
<td>Nasrullah et al. 2003</td>
</tr>
<tr>
<td>5.90</td>
<td>Harvested at wet and dry season</td>
<td>Nigeria</td>
<td>Bamigboye et al. 2013</td>
</tr>
<tr>
<td>7.22</td>
<td>New leaves</td>
<td>Nepal</td>
<td>Thakur et al. 2014</td>
</tr>
<tr>
<td>7.05</td>
<td>The portion of the grass consumed by the elephant that was analyzed</td>
<td>India</td>
<td>Das et al. 2014</td>
</tr>
<tr>
<td>4.00</td>
<td>Before flowering</td>
<td>Cameroon</td>
<td>Tendonkeng et al. 2015</td>
</tr>
</tbody>
</table>

Table 1 shows that, in general, crude protein contents of the plant harvested at the age of 4 weeks or less were above 7%, a value that is considered as the minimum level of crude protein required for optimum rumen function (Milford and Haydock 1965). None of the reported crude protein content is sufficient to meet the minimum requirement of the crude protein of 15% for lactation and growth (McDonald et al. 2002). This optimum harvest interval of 4 weeks was shorter than the optimum harvest interval in elephant grass that could maintain the crude protein level above 7% until 8 weeks of regrowth (Manyawu et al. 2003; Njoka-Njiru et al. 2006). This level indicated that in order to obtain higher animal production, *Imperata* has to be harvested at a very young stage of growth and this might harm the regrowth of the grass and make *Imperata* pasture vulnerable to weed invasion (Falvey et al. 1977).

Maximum crude protein content of *Imperata* of 9.51 was obtained when the grass was harvested at two week intervals (Table 1), but this value was much lower than the crude protein value of 20.4% that was obtained when elephant grass was harvested at the same interval (Manyawu et al. 2003). The lower crude protein content in *Imperata* indicated that to obtain the same level of animal production, animals offered *Imperata* need protein supplementation and it might be more expensive compared to feeding of elephant grass.

Fiber content

Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents of *Imperata* grass as reported by some
workers are presented in Table 2. *Imperata* grass contains varied amounts of NDF, ADF and lignin, depending mainly at stage of maturity. The average NDF, ADF, and ADL content were 73.4%, 50.1% and 8.05%, respectively.

Table 2: Fiber content of *Imperata cylindrica*

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvested at 20 and 40 days of regrowth</td>
<td>Van Soest, 1994</td>
</tr>
<tr>
<td>Harvested at 8 weeks interval</td>
<td>Senanayake, 1995</td>
</tr>
<tr>
<td>Harvested during dry season</td>
<td>Sutedi et al. 2001</td>
</tr>
<tr>
<td>Harvested at heading stage</td>
<td>Nasrullah et al. 2003</td>
</tr>
<tr>
<td>New leaves</td>
<td>Thakur et al. 2014</td>
</tr>
<tr>
<td>Harvested during spring</td>
<td>Laudadio et al. 2009</td>
</tr>
<tr>
<td>Harvested during winter and summer</td>
<td>Das et al. 2014</td>
</tr>
</tbody>
</table>

With the increase in harvesting interval, NDF, ADF and LDL content decreased. The increase in NDF, ADF and lignin with age is related to physiological changes that occur as the plant ages, that lead to decrease in cell contents, accompanied by an increase in cell wall fiber components.

NDF and ADF content could be used to categorize feed quality. Singh and Oosting (1992) pointed out that roughage feeds containing NDF values less than 45% are classified as high quality, 45% to 65% are classified as medium quality and higher than 65% as low quality. From Table 2, it can be seen that all NDF values were higher than 65%, even when it was harvested at 20 days of regrowth. Based on this finding, all reported *Imperata* grass can be classified as low quality and its high NDF values can be a limiting factor to dry matter intake, as dry matter intake and NDF content are negatively correlated (Van Soest 1994).

Based on its ADF values, *Imperata* grass can also be classified as low quality forage, because all the reported ADF values were above 40%. According to Kellems and Church (2001), roughages with less than 40% ADF are categorized as high quality and those with greater than 40% as poor quality. The higher value of reported ADF in this study could be indicative of lower digestibility as ADF value and digestibility are negatively correlated (Van Soest 1994).

**Digestibility**

Digestibilities of *Imperata* grass harvested at various intervals and stages of growth are shown in Table 3. IVDMD of *Imperata* was ranged from 36.8% to 70.0%. These values were lower than those for digestibility of elephant grass of 63.6% to 72.8% as reported by Manyawu et al. (2003). With increasing harvest interval, digestibility increased. The reduction of digestibility as maturity advanced is related to higher ADL contents of the mature plant. The ADL fraction is indigestible, and forms complexes with structural carbohydrates and this hinders exposure of structural carbohydrate to microbial enzymatic attack.
Table 3: Digestibility of *Imperata cylindrica*

<table>
<thead>
<tr>
<th>IVDMD (%)</th>
<th>IVOMD (%)</th>
<th>Conditions</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.0 and &lt; 40.0</td>
<td></td>
<td>Harvested at young and 150 days of age</td>
<td>Falvey et al. 1979</td>
</tr>
<tr>
<td>36.8 and 50.6</td>
<td></td>
<td>Cutting interval of 75 and 25 days, respectively</td>
<td>Rusdy et al. 1995</td>
</tr>
<tr>
<td>51.4</td>
<td></td>
<td>Cutting interval of 8 weeks</td>
<td>Senanayake, 1995</td>
</tr>
<tr>
<td>44.7</td>
<td></td>
<td>Harvested at heading stage</td>
<td>Nasrullah et al. 2003</td>
</tr>
<tr>
<td>38.0</td>
<td></td>
<td>Harvested in wet and dry season</td>
<td>Bahar and Lisson, 2010</td>
</tr>
<tr>
<td>31.6</td>
<td>42.3</td>
<td>Harvested at the stage of straw</td>
<td>Tendonkeng et al. 2015</td>
</tr>
</tbody>
</table>

Besides the harvest interval, digestibility of *Imperata* is also affected by the temperature. This is evidenced by the highest digestibility of 70% when grown in cooler area of northern Thailand, although it declined to below 40% after 150 days of age (Falvey et al. 1979).

The average values of IVOMD of *Imperata* was 42.3% which was lower than the critical level of 65% required for feeds to be considered as having acceptable digestibility. Forage with IVOMD value of <65% can be classified as low quality and when fed to animals, it may result in reduced dry matter intake (Moore and Mott, 1973). The low digestibility of mature *Imperata* may place this grass in the range where “rumen fill” would be the limiting factor to dry matter intake and animal production.

*Imperata* was less digestible than *Setaria anceps* Stapf. ex Massey, *Cenchrus ciliaris* L. and *Pennisetum purpureum* L. at the same age (Holmes et al. 1976). The low digestibility of *Imperata* may be reflected in reduced rate of passage and intake. Consequently, lower animal production would be expected from *Imperata* than from improved tropical grasses.

Animal production

Most of the literature reporting live weight gains of animals grazing *Imperata* pasture came from studies undertaken in South East Asia. As animal feed, *Imperata* has a low nutritive value, especially with advancing maturity, so it is not surprising that productivity of animals grazing *Imperata* pasture is also low. Replacement with improved species or supplementation with concentrates or legume forages, has significantly improved animal production. In Papua New Guinea, Holmes et al. (1976) recorded live weight gains per animal of 0.22, 0.25, 0.21 and 0.20 kg day\(^{-1}\) at the stocking rates of 1.29, 1.06, 0.83 and 0.61 ha beast\(^{-1}\), respectively, for heifers grazing on *Imperata* pasture as compared with gain of 0.45 kg day\(^{-1}\) for heifers grazing *Panicum maximum* and legume mixed pasture at stocking rates of 1.69 and 2.17 beast/ha. Chadhokar (1977) reported that average daily weight gain per head of cattle grazing on *Imperata* pasture over two years was 0.19, but it increased to 0.25 kg with legume stylo oversowing. In the Philippines, Magadan et al. (1974) noted live weight gain of cattle grazing *Imperata* at stocking rate of 1 beast/ha was 100 kg/ha/year, compared to two animal unit and live weight gain of 305 kg/ha/year on sown legume/grass pasture. In Africa, the growth of cattle grazing *Imperata* pasture was also low; only 26.6 kg/ha/year, but...
it can be improved to 174.8 kg/year when supplemented with *Leucaena leucocephala*, (Lam) de Wit leaves. However, this animal production from *Imperata* legume pasture mixture was much lower compared to elephant grass – centro mixture that attained of 474.0 kg/ha/year with a stocking rate of two animal units/ha (Moog 1991).

Besides supplementation with legume forage, the growth of cattle could be improved by supplementation with protein bypass sources such as copra meal and readily fermentable carbohydrates source such as molasses. Galgal and Komolong (2000) obtained live weight gain of cattle grazing *Imperata* pasture of 0.632 kg/day when it was supplemented with copra meal, molasses and urea, compared to the control of 0.377 kg/day. However, the lower nutritive value of *Imperata* compared to improved grass makes supplementation with concentrate more expensive and this might not be economical under prevailing conditions in most developing countries.

**Conclusion**

The review affirms the earlier findings of the limited production potential of *Imperata* as animal feed compared to improved grass or legume forages. Before practical and cheap methods of replacing *Imperata* with improved forage species are available, improving animal productivity from this grass can be attained by regulating cutting interval, supplementation with concentrates or oversowing with legume forages. Introduction of tree legume forages into *Imperata* grassland also is preferable because it can provide high-quality forage to animals and in the long term, and can control *Imperata* growth by providing shade.

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