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Oat as Green Fodder and Its Intercropping Benefits: A Review

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ABSTRACT

Oat (*Avena sativa* L.) has been grown in the past hundred years, though its production potential is yet to be explored to combat the winter forage scarcity. The oats can be grown in combination with other fodder legumes such as berseem, lucerne, pea and vetch. In order to increase productivity per unit area, there is a need to test the promising forage species having high forage yield potential and quality as well the compatibility for mix cropping. The present review explores the productive potential of oat combined with promising legumes in terms of dry matter and chemical composition. The present review summarizes the benefits of oat-legume intercropping on forage yield and quality. Further, it discusses that oats in combination with pea and or vetch could be a potential model of intercropping to attain an increased forage dry matter yield that could address the situation of mitigating DM shortage, especially during winter season.

Key words: Benefits, Intercropping, Legumes, Oat.

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Oat

Oat (*Avena sativa* L.) is commonly known as *Jai* in Nepali and is one of the most important cultivated winter fodder crops. During winter season, livestock such as cattle, buffalo, goat, *etc.* depend mainly on rice straw, by-products and semi-dried grasses present in barren lands leading to the low production and productivity of livestock. Thus, to alleviate the acute shortage of green fodder during the lean period of winter season oat fodder can be cultivated successfully in rice fallow lands in both plain and hilly areas (Luikham *et al*. 2015). It has been adapted to a wide range of soil types and climatic conditions. It is promising for multi-cut, fits well in farming systems for quality and quantity fodder supply during winter feed scarcity period (December to April). In an estimation of FAO (2010/011), oat ranked sixth in the global context of wheat, maize, rice, barley and sorghumas a food cropand ranked first in the world within the fodder production statistics. Oats are considered most important winter fodder crop. Oat is mostly fed as green but the surplus is converted into silage or hay to use during fodder deficit periods (Suttie and Reynolds, 2004). Oats are quick growing, palatable, succulent and nutritious (Suttie and Reynolds, 2004) and form an excellent combination when fed along with other winter fodder legumes such as berseem, lucerne, pea and vetch.

Morphology

Oat is an erect annual grass with a fairly good tillering habit that could attain a height of 1-2 m. The panicles are lax and effuse. The inflorescence may be equilateral or unilateral. The main axis and lateral branches end in a single apical spikelet. The grain is long and slender or spindle-shaped and usually covered with fine hair at the upper end (Devkota, *et al*., 2015). The leaves may have a length of 25 cm and more. Roots are fibrous (Relwani, 1979).

Distribution

Oats are grown in more than 50 countries but statistical information is mainly concerned with the grain (Heuzé, *et al*., 2016). Although oats are grown as a dual crop (forage and grain), their introduction in the commercial market is rare. However, there is no reliable estimation of worldwide oat forage acreage and production in general (Suttie *et al*., 2004).

Oats remain an important grain crop for people in marginal ecologies throughout the developing world and in developed economies (Suttie and Reynolds, 2004). It has been estimated that livestock grain feed is still the primary use of oat crops, accounting for an average of around 74% of the world's total usage in 1991 to 1992 (Welch, 1995).

Stevens *et al.* (2004) found that oats are well adapted to a wide range of soil types but perform better on acid soils. They are mostly grown in cool moist climates and can be sensitive to hot, dry weather from head emergence through to maturity (Suttie and Reynolds, 2004). Oats are grown widely throughout Punjab in late winter through spring yet none are reported in FAOSTAT for India, Pakistan or neighboring countries.

Stevens *et al*. (2004) noted that Russia, countries of the former Soviet Union, the United States, Canada, Germany and Poland account for about 75 percent of the world's supply of grain, seed and industrial grade oats. Since the 1960s, the proportion of oats used for feed has declined in the US and Canada, remained unchanged in the former Soviet Union countries and Poland and increased slightly in Germany (Stevens *et al*., 2004). The leading export

countries of oat grain are Canada, Finland, Sweden, Australia and Argentina.

Nutritional qualities of fodder legumes

The forage quality reveals the amount of nutrient (chemical) composition, palatability and intake, digestibility, anti-nutritional factors in association with livestock performance (Ingalls *et al*., 1965). Some of the factors such as cultivar, stage of maturity at harvest and storage methods are some of the important points that might affect the chemical composition and nutritional value thereof. Besides these, environmental factors such as soil type and fertility, day length, the temperature during plant growth are also important in determining quality (Ball, 2000). Likewise, Van Soest (1986) reported that forage intake is dependent upon the cell wall content (ADF), while digestibility is dependent on the cell wall (NDF) content and its availability.

Various factors such as moisture, temperature and the amount of sunlight influence forage quality. The temperature is one of the environmental factors that could directly affect the fodder quality. A rise in temperature increases cell wall constituents, increase lignification; decrease soluble carbohydrates concentration and decrease digestibility has been reported (Pearson and Ison, 1997). It also reduces the leaf to stem ratio of the forage, which directly affects the digestibility of the forage dry matter because of the lower digestibility of the stems in relation to the leaf (Buxton *et al.,* 1995). Forages digestibility decreases by about 0.5 to 7 percentage units per 10°C increase in temperature which indicates that the forage grown in the winter season are better in quality than in summer.

Agronomic factors and forage quality

Herbage maturity in response to environmental factors are the major causes of agronomic variation in forage quality. The other factor relevant to animal nutrition is the variation of quality in terms of a physical and chemical composition expressed by individual forage species that may respond differently to environmental stimuli (Abeysekara, 2003). The temperature, light and moisture in decreasing order are the dominant factors affecting the plant physical nature and chemical composition (Van Soest, 1994).

Intercropping oat with other species

Intercropping is an old-style but a very extensive agricultural practice used in low input cropping systems in the world (Anil *et al*., 1998). During the 20th century, there was a shift from mainly labor-intensive systems to more optimized cropping through the use of external inputs, especially synthetic fertilizers and pesticides (Crews and Peoples, 2004). There has been a growing interest in intercropping systems in developed countries due to the increasing awareness of environmental degradation arising from the heavy use of non-renewable resources in mono-cropping (Fujita *et al*.1992). Intercropping systems, especially cereals with legumes, have several major benefits such as higher total yield and better land use efficiency (Dhima *et al*., 2007), stable crop yields (Lithourgidis *et al*. 2006), better utilization of resources (Javanmard *et al*. 2009), improved soil conservation (Anil *et al*., 1998) and better control of pests and weeds (Banik *et al*., 2006; Vasilakoglou *et al*. 2008).

Characteristics of some commonly used fodder species in intercropping

Field pea (*Pisum sativum* L.)

It is an important crop and can be grown successfully in Terai (<100 m) during winter to a high mountain (3000 m) during summer months. Peas are grown alone or in combination with cereals for silage and green fodder (Elzebroek and Wind, 2008). Peas and other legumes are desirable in crop rotations because they break up disease and pest cycles, provide nitrogen, improve soil microbe diversity and activity, improve soil aggregation, conserve soil water and provide economic diversity (Biederbeck, *et al*., 2005; Chen *et al*., 2006). Pea is grown with cereal crop like oat to enhance the forage quality.

Description

It is a rapid-growing, multipurpose, herbaceous legume with angular or roundish hollow stems covered with a waxy bloom. The plant has a taproot that can grow as deep as 1 m with numerous lateral roots. Leaves are alternate, a compound with 1-3 pairs of leaflets borne on petioles with several pairs of tendrils. Large leaf-like stipules are inserted at the base of the leaves (FAO, 2011; Muehlbauer *et al*., 1997; Oelke *et al*., 1991). The inflorescence is a raceme that bears white, pink or purple flowers. Pods are dehiscent and contain several seeds that may be globular or angled, smooth or wrinkled (FAO, 2011; Muehlbauer *et al*., 1997). Peas are a high-yielding, short-term crop with high protein content (Fraser *et al*., 2001).

Pea *(Pisum sativum)* has a large genetic diversity. There are winters and spring varieties, leafy and leafless, early- or late-maturing (Heuzé *et al*., 2015). Seeds can be of varying color, shape and size. The pea varieties, in general, can be classified into garden peas (green peas are eaten as vegetables), field peas (dried peas for feed and food) and tiss, that are grown primarily for forage. An example of the latter varieties is the Austrian Winter Pea (Heuzé *et al*., 2015). Pea forage can also be used for green manure (Maxted *et al*., 2001; Oelke *et al*., 1991).

Adaptation

Peas are adapted to different soil types but can perform wellon fertile, light-textured, well-drained soils (Hartmann *et al*., 1988; Elzebroek and Wind, 2008). The peas are sensitive to soil salinity and extreme acidity. The ideal soil pH range for pea production is 5.5 to 7.0 (Hartmann *et al*., 1988). Peas grow well with 16 to 39 inches annual precipitation (Elzebroek and Wind, 2008).

Oat and pea intercrop

Intercropping of pea+oat or pea+barley is the traditional system of agriculture. Peas are important feed grain legumes

for animal production and are widely grown for hay, pasture or silage production either alone or mixed with cereals (McKenzie and Spaner, 1999). Peas as a monocrop, result in reductions in forage and seed yield due to severe lodging after flowering (Heath and Hebblethwaite, 1985; Stelling, 1997). Thus, peas are often sown in mixtures with cereals that have an upright stature (Uzun and Acikgoz, 1998). Tall varieties of peas are cultivated with cereals, to reduce lodging and increase hay yield and quality (Robinson, 1960; Anderson, 1975; Droushiotis, 1989; Tan and Serin, 1996).

The selection of plants, mixture rates and stages of cutting are very important in legume-cereal mixed cropping, so as to provide protein and carbohydrate sources for livestock (Karadag and Buyukburc, 2003). Previous several studies had confirmed the suitability of fodder species to be used in a pea mixture, though variable results had been obtained. There are also several reports that mixed cropping pea with oat increased hay yield (Robinson, 1960; Mitchell, 1983), while in other studies reported that pea with barley should be mixed (Chapko *et al*., 1991). Seed rates in the grass-legume mixture are important for high yield and fodder value. The grass ratio in the hay can be higher than the sowing ratio. The plant density of cereals are high in the hay due to their characteristic of tillering and the hay yield; while crude protein ratio and yield decrease (Bayram and Celik, 1999; Kwabiah, 2005; Geijersstam and Martensson, 2006).

Vetch (*Vicia sativa*)

Vetch is an important legume that can be successfully grown in both terai and mid hills and it is noted for its ability to fix large quantities of N about 110 kg per hectare. It is grown for hay, pasture, silage, seed or as interim cover on disturbed soil.Common vetch also used as a valuable cover crop and green manure (Sattell *et al.* 1998).

Description

The common vetch (*Vicia sativa* L.) is an annual scrambling and climbing legume. It has a slender highly branched taproot that can go down to 1-1.5 m deep (Heuzé *et al*., 2015). The stems are thin, angled and procumbent and branched, could attain up to 2 m in height. The leaves are compound with 3-8 pairs of opposite leaflets and 2-3 terminal tendrils that help climbing. The leaflets are elliptic or oblong, 1.5-3.5 cm long, 5-15 mm wide. Stems and leaves are mainly glabrous. The flowers, borne on leaf axils, are blue to purple, sometimes white, mostly paired, sometimes unique (Heuzé *et al*., 2015). Pods are cylindrical, 3.5-8 cm long and erect; with 4-12 rounds, but flattened, black to brownish seeds (FAO, 2010; Sarep, 2006; Sattell *et al*. 1998).

The common vetch provides palatable forage (fresh, hay and silage) and grain to livestock of monogastric species (including humans). Common vetch also provides a valuable cover crop and green manure (Sattell *et al*. 1998).

Oat and Vetch Intercrop

Common vetch (*Vicia sativa* L.) is an annual climber legume, which is usually grown in mixtures with small grain cereals for hay or as fodder. These mixtures improve growth conditions and enhance forage quality (Anil *et al*. 1998). Common vetch or cereals alone do not provide satisfactory results for dry matter yield (Osman and Nersoyan, 1986). The common vetch is low-yielding, particularly in areas with low rainfall (Hadjichristodoulou, 1978) and hinders harvest because it normally spreads on the soil surface (Robinson, 1969). On the other hand, small grain cereals provide high fodder yields in terms of dry weight but they produce low-quality forage (Lawes and Jones, 1971). Forage quality of cereal hay is usually lower than that required to meet satisfactory production levels for many categories of livestock. In mixtures, companion cereals provide structural support for common vetch growth improves light interception and facilitate mechanical harvest, whereas common vetch in mixtures improves the forage quality (Thompson *etal*. 1992). The other advantages of mixtures of Vetch and Cereals include greater uptake of water and nutrients, enhanced weed suppression and increased soil conservation (Stern, 1993; Ranells and Wagger, 1997; Anil *et al*. 1998) Caballero and Goicoechea (1986) and Thomson *et al*. (1990) reported that the most suitable cereal for mixtures with common vetch is oat (*Avena sativa* L.). Intercropping oats with forage legumes such as vetch improves both the quantity and the quality of the hay (Khalili, Varvikko and Crosse, 1992; Mpairwe *et al*. (2003), Umunna *et al*. (1995). There have been several reports that supplementation of oat-vetch hay with concentrates or with a high protein forage legume hay increased milk production in crossbred cows (*Bostaurus* × *Bosindicus*) (Khalili *et al*. 1994); Khalili *et al*.1992); Mpairwe *et al*. 2003).

Dry matter yield of forage species and their mixture

Grass-legume intercropping plays a key role in increasing dry matter productivity. Research findings of Haq *et al*. (2018) showed that oats-vetch combination was found productive than oats-pea combination. This result was similar to the findings of (Devkota *et al*. 2015) in which the Netra-Vetch combination performed relatively better than Netra-Pea, though it was statistically similar. However, oat-pea mixture was found to be better combination than oat-vetch in some of the research findings. Robinson (1960) showed that oat-pea mixture was superior to oats alone or oats-vetch in protein yield per acre and dry yield. Also, (Staniak*etal*.2014) found that the oat-pea mixtures were efficient than oat-vetch mixtures in both cases either fertilization with compost or without fertilization.The inclusion of oats with legumes significantly increased total herbage yields relative to legume monocultures and this is consistent with most of other studies with vetch (Munzer, 1993; Wassermann *et al*.1984) and pasture legumes (Martiniello, 1999; Wassermann *et al*. 1984; Wiersma *et al*. 1999).

It was observed that the dry matter productivity of oat with lucerne (2:1) was found higher than sole cropping and other intercropping systems of oat with lucerne (Ganvit *et al.* 2018). Ross *et al*. (2004) reported that intercropping oat

with pulse crops produced, greater DM yield than intercropping barley or triticale with pulse crops, but intercrops with barley or triticale were better in terms of quality and protein content than intercrops with oat.

Cabbelero *et al.* (1995) found that oat-vetch mixtures produced 34% more forage yield than common vetch alone, but 57% less than monoculture oat. The highest dry matter yield was found in (25% vetch and 75% oat combination) being followed by 50% vetch + 50% oat, 75% vetch + 25% oat mixtures (Tuna and Orak, 2007). The intercropping of oats with lucerne and oat with berseem produced greater green and DM yields than those of sole crops of either legume (Muhammed and Serkan, 2018).

Moreira (1989) reported an increased interest in the use of hairy vetch (*Vicia villosa*) with oats in Portugal, suggesting that yields of 12 t DM ha) were possible under high-nutrient conditions indicating the necessity of higher proportion of oat seeds used.

Similarly, research finding in Australia, reported that oats contributed 90% of the total DM yield in an oat peaintercrop, whether sown as mixtures or in separate rows (Mason and Pritchard,1987).

The benefits of cereal legume mixtures may vary with sowing methods and mixture combinations (Altin and Gokkus, 1988).

Chemical composition of forage species and mixture

Crude protein

The crude protein (CP) content is one of the most important criteria for forage quality evaluation (Caballero *et al*. 1995; Aseefan and ledin, 2001). Haq *et al*. (2018) reported that the CP content of the oat-vetch mixture, oats-pea mixture was higher than the oats grown alone, while it was lower than pea andvetch monoculture.Research has shown that the oats grown with the peas can provide excellent tonnage and high-quality forage, generally increased the crude protein content by 2 to 4% (Owens *et al*. 2007).

In field crop production, it has been established that the legume-cereal intercrops may produce higher grain yield and protein yields as compared to the sole cereal crops (Jensen,1996; Lauk and Lauk, 2005) and show greater yield stability than when growing cereals and legumes as sole crops (Wiley, 1979; Ofori and Stem,1987)

Pea-barley yields were higher than those of oat-pea, however the oat-pea intercrop was superior in terms of forage quality, increasing the CP content by 4.4% (Anil, 1998).

Pea-cereal mixtures have an advantage over cereal sole crops with regard to protein yield and are particularly suitable for organic farming. The pea-oat intercrop provided the highest grain and protein yield compared to other oat-barley and oat wheat intercrop (Lauk and Lauk, 2008).

Crude fiber

The crude fiber content of mixture oat-vetch mixture was higher than oat-pea mixture is supported by the findings of (Devkota *et al*. 2015). The major reason might be due to the increased fiber content with prolonged growing period and higher fiber content in cereal oat and legume vetch. This may be due to the major contribution of oats to the fiber content of mixtures. Findings of (Paulson *et al*. 2008) also suggested that the grass contain higher fiber content than the legumes.

Total ash

It was observed that the oats-vetch mixture had higher ash content than vetch alone (Assefa and Ledin, 2001). In contrast, it was found that the ash content of pea and vetch was generally higher than that of oat-legume mixture at all harvests (Kaiser *et al*. 2007). Intercropping cereal with legumes can improve the forage quality in terms of the ash content of the mixture than cereal crop grown alone. Anil *et al*. (2000) reported that ash content was increased by intercropping of maize and runner bean. Similarly, Mason and Pritchard (1987) stated that mineral absorption increases due to complementary effects between components of maize-soybean intercropping.

CONCLUSION

The present review illustrates that that oats-legume mixture had the potential for herbage productivity in abandoned lands with minimum tillage and are likely to play a crucial role in providing quality and quantity feed for livestock enterprises as well. Oat-legume mixture could significantly increase the DM and nutritive value, suggesting a better option to utilize per unit area of land for a maximum DM harvest without jeopardizing the quality issue and with the potential to minimize weed infestation.

Further, Oats in combination with pea and or vetch could or other legumes would be a potential model of intercropping to attain an increased yield stability and yield per unit area and support the sustainable cropping system. This combination could be successfully extrapolated at farmers' field.

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