16

INTERCROPPING OF LEGUMES WITH CEREAL CROPS IN PARTICULAR WITH THE PERENNIALS TO ENHANCE FORAGE YIELDS AND QUALITY

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ABSTRACT:

Intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms. Spatial arrangements of plants, planting rates, and maturity dates must be considered when planning intercrops. Intercrops can be more productive than growing pure stands. Many different intercrop systems are discussed, including mixed intercropping, strip cropping, and traditional intercropping arrangements. Pest management benefits can also be realized from intercropping due to increased diversity. Harvesting options for intercrops include hand harvest, machine harvest for on-farm feed, and animal harvest of the standing crop.

Since landholdings in Pakistan's mountainous Northern Areas are minute, farmers aim to maximize production per unit of area per season. An integrated approach that complements rather than competes with the existing farming system was needed. Forage production and availability have been affected by sole cropping vs. intercropping of forage legumes with cereals. To obtain early and good yields on small holdings under severe winter conditions, compatible fodder crops can be planted in mixtures to produce high fodder yields with good quality. Leguminous dwarf fodders like berseem can be mixed with taller species such as oats, ryegrass, brassicas etc. Lucerne is considered one of the most important leguminous fodder crops in Pakistan's Northern Areas.

Important priorities for future research include evaluating the potential for suitable cash cropping, promoting intercropping of potential fodder crops that might provide a more ensured/ continuous supply over the winter, and improving the nutritional content of animal diets with, for example, the introduction/evaluation of improved alfalfa and fodder oats.

Keywords: intercropping, berseem, lucerne, alfalfa, fodder oats, soil fertility, sorghum

INTRODUCTION

Historically, intercropping has commonly been practiced throughout the developing world. Due to limited land holdings, farmers usually practice an integrated and subsistence type of farming system that is not very flexible. For example, in Africa, corn (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.) Moench), or millet (*Panicum* and *Pennisetum* spp.) are grown with pumpkin (*Cucurbita* spp.) cowpea (*Vigna unguiculata* (L.) Walp), pigeon pea (*Cajanus cajan* (L.) Millsp.), or beans (*Phaseolus* spp.). Cocoa (*Theobroma cacao* L.) is grown with yams (*Dioscorea* spp.) or cassava (*Manihot esculenta* Crantz). In the tropical Americas, maize (*Zea mays* L.) is grown with beans and squash (*Cucurbita* spp.). In both Africa and Latin America, beans or peas (*Pisum sativum* L.) climb tall cornstalks while pumpkins or squash cover the ground below. In these countries, many farmers have limited access to agricultural chemicals and equipment so prevalent in the developed world. Besides, intercropping is much less risky in that if one crop fails others may still be harvested (Machado, 2009).

Intercropping to reduce risk was a common practice in the United States and Europe before the 1940s, (Kass, 1978; Andersen, 2005), but the practice faded from significance as advances in mechanization and the availability of relatively cheap inorganic fertilizers and pesticides made monocropping more attractive. Paralleling the development of high-yielding varieties and production of cheap fertilizer that brought about the Green Revolution to feed rapidly growing populations, the practice of monocropping proved effective and economical (Horwith, 1985).

On the other hand, with fertilizer shortages developing and costs escalating, intercropping with legumes is again becoming desirable. The composite fertilizer price increased 113 percent between 2000 and 2007, led by gains in nitrogen prices (Huang, 2007). Meanwhile, environmental problems associated with heavy fertilizer use, e.g. surface- and groundwater pollution, soil acidification, and ammonia volatilization are becoming well known, and as synthetic fertilizer is a petroleum-based product, prices will continue to increase. Hence, fodder legumes such as alfalfa or lucerne (*Medicago sativa*), berseem (*Trifolium alexandrinum*), shaftal (*Trifolium resupinatum*), vetch (*Vicia sativa*), and cowpea (*Vigna unguiculata*) can be grown in association with fruit trees, providing fodder for livestock as well as improving soil fertility through biological nitrogen fixation. Oats might be a good choice for mixed planting with berseem or lucerne to maximize yields per unit area. There are several options available to enhance productivity through intercropping of several different crops. Some of these options are summarized below.

LEGUMES INTER-PLANTED IN ORCHARDS

The majority of the region's farmers rear livestock and also grow fruit trees. Therefore, an integrated approach that complements rather than competes with the existing farming system is required. In order to obtain superior quality fodder, improve soil fertility, and subsequently enhance fruit yields and quality, farmers intercrop lucerne, red clover, berseem, shaftal, or vetch in the orchards. Lucerne is considered one of the most important leguminous fodder crops that provide high quality hay for winter feeding.

Three improved winter active lucerne cultivars i.e. 'Sundar', 'Sequel', and 'Aquarius' were evaluated with a local cultivar in five to seven year old apple orchards in Chilas and Gilgit. 'Sundar' excelled over all cultivars in the double crop areas. With it, farmers have been able to harvest lucerne throughout the year on land protected from uncontrolled grazing.

Multicut forage sorghums (sorghum/Sudan grass hybrids), which were unknown in the area, provided an excellent means of increasing summer fodder production by producing three to four times as much fodder as the local maize. Local maize yields on average 39 tonnes/ha of green fodder, whereas the sorghum hybrid yields ranged from 110 to 138 tonnes/ha with an average of 127.7 tonnes/ha of air-dry material.

ENHANCED FODDER YIELDS, QUALITY AND SOIL FERTILITY PER UNIT AREA PER SEASON

In order to obtain early and good yields on small holdings in winter, compatible fodder crops may be sown in mixture to produce higher fodder yields and better quality per unit area per season. Short-statured leguminous fodders such as lucerne, berseem, and vetch can be mixed with oats, barley, ryegrass, brassica etc. Lucerne + oats, berseem + oats and shaftal +oats produced greater yields of green forage than did monocultures of the respective crops (Table 1).

TABLE 1. YIELDS OF SOME LEGUMINOUS FORAGE CROPS (TONNES/HA)

VARIETY	GREEN FORAGE	AIR DRY MATTER
LOCAL LUCERNE	55	19
SUNDER LUCERNE	120	45
SUNDER + OATS	190	58
SHAFTAL	45	14
SHAFTAL+OATS	80	25
BERSEEM	89	28
BERSEEM + OATS	130	47
OATS	90	38

Source: Dost, 1997

Oat + vetch and barley + vetch combinations produced 132-135 and 73-76 tonnes/ha of green fodder compared to 100 -105 and 56 -59 tonnes/ha pure oat and barley stands at both locations respectively in the 1 260 to 1 490 m altitude band (Table 2).

TABLE 2. GREEN AND DRY MATTER YIELDS (TONNES/HA) OF OATS, BARLEY, AND VETCH AT TWO SITES IN 1994-1997

CROPS	GILGIT (1490 m asl)		CHILAS (1260 m asl)	
	GREEN	DRY	GREEN	DRY
Oats	100	22	105	23
Oats + vetch	132	26	135	29
Barley	56	12	59	14
Barley + vetch	73	16	76	17

Source: Dost, 1997

A deep-rooted crop like lucerne can be intercropped with shallow-rooted crops like oats, rye, barley or a brassica; the annuals are usually sown between the rows of perennial fodder. Intercropping has a number of advantages over monocultures: more than one crop per season per unit area; easier weed control; higher yields than in pure sown crops; and fodder of better quality. Oats were intercropped in winter active lucerne and red clover in rows 30 cm apart at several sites. The intercropping of lucerne with oats produced greater green and DM yields than those of sole crops of either legume (Table 3).

Intercropping of oats with berseem clover provided earlier and greater fodder yields, and increased milk production by as much as 20 litres per cow per month on average compared with traditional practices. At the same time, the demand for purchased concentrates was reduced by 20 kg per month per animal and lactation period was extended by an extra two months (Dost, 1995).

TABLE 3. GREEN AND DRY MATTER YIELDS (TONNES/HA) OF LEGUMES AND OATS AT GILGIT IN 1993-1994

TREATMENT	GREEN YIELD	DRY MATTER
Lucerne	70	18
lucerne + Oats	115	30
Berseem	80	17
Berseem + Oats	135	30
Redclover	63	16
Redclover + oats	94	26

Source: Dost, 1995

Multiple cropping or mixed sowing techniques were carried out in North Pakistan by Dost (1997). The details are presented in Table 4.

TABLE 4. EFFECT OF MIXED SOWING ON GREEN AND DRY MATTER YIELDS (TONNES/HA) OF LUCERNE, RED CLOVER, AND OATS AT THREE SITES IN 1996-1997

TREATMENT	SULTANABAD		RAHIMABAD		SALING	
	GREEN	DRY	GREEN	DRY	GREEN	DRY
Lucerne cv. Sundar	110	30	105	26	68	20
Red clover	60	16	62	18	50	13
Oats	100	32	95	30	80	26
Lucerne + oats	140	39	136	37	102	30
Red clover + lucerne	115	32	105	26	70	22
Red clover + oats	90	26	93	28	75	23

Source: Dost. 1997

Oat has been used as a companion crop for sowing forages since the early 1990s in western Canada. In central Saskatchewan, oat was used at rates from 18 kg/ha to 72 kg/ha with 17 kg/ha sweet clover (*Melilotus officinalis*, *M. alba*) (Tinline, 1924). In southern Saskatchewan, Jefferson and Zentner (1994) sowed oats as a companion crop with lucerne on irrigated land. Lucerne sown alone produced much less than oat intercropped with lucerne or oat sown alone in the establishment year.

In Minnesota, Hartman and Sturtman (1983) recommended a seeding rate of 54-72 kg/ha for oat when used as a companion crop, compared with 72-90 kg/ha when sown alone for grain. Peter (1961) reported that oats cut for forage at the late dough stage plus a cut of intersown lucerne yielded more than lucerne established with or without herbicides and harvested twice in the establishment year. In contrast, Brink and Marten (1986) showed that oat as a companion crop to lucerne had inferior forage quality compared with barley when the mixture was harvested in the sowing year. In California, Lanini *et al.* (1999) reported that oat intersown into an established (but declining) lucerne stand was comparable to using paraquat

herbicide for weed control, with the advantage of increasing first harvest forage yield. Marshal, McDaniel and Cregger (1992) suggested that growers planning to use oats as a companion crop should use early maturing, lodging-resistant cultivars, and remove the oat forage early to favour the establishing perennial forage crop.

NON WINTER-DORMANT VERSUS WINTER-DORMANT LUCERNE VARIETIES

One of the most important questions is whether we need perennials, winter-dormant or non-winter-dormant cultivars as they might affect the biomass as well as seed yields in the long run. Several perennial non-winter-dormant and winter-dormant varieties of lucerne were evaluated at three sites during 1993-1995. The details are presented in Table 5. Non-winter-dormant lucerne (Sundar being the main cultivar) has been extremely successful at all three sites. They may suffer some frost damage at high altitudes but grow throughout the year and yield more than twice as much as the winter dormant landrace in double-crop areas below 2 000 m. They also provided maximum green feed in the critical December-January period.

TABLE 5. GREEN AND DRY MATTER YIELDS (TONNES/HA) OF LUCERNE VARIETIES

VARIETIES	SITES					
	CHILAS		GILGIT		SKARDU	
	Green fodder	Dry matter	Green fodder	Dry matter	Green fodder	Dry matter
SUNDAR	165	50	174	52	90	26
MISASIRSA	98	32	117	34	74	20
PIONEER	92	29	95	30	86	22
SANORA	90	27	84	24	73	20
ILLUNICO	71	22	68	22	70	19
TYPE 8/9	100	32	96	30	74	21
POWERA	58	19	61	19	68	18
LOCAL	55	16	60	18	57	17
AVERAGE	91.13	28.38	94.38	28.62	73.25	20.38

Source: Dost, 1995

SINGLE CUT VERSUS MULTICUT FORAGE VARIETIES

Oat provides multiple cuts, tillers profusely, and yields more than wheat and barley in northern Pakistan. Standing oats can be cut progressively, releasing land earlier than normal for follow-on crops or relay cropping. Any remaining oats can be dried as hay. This coincides with optimum soil moisture for land cultivation and sowing of the following crop, and also allows small areas or peripheral lines on terraces to be saved for seed. In many, but not all instances, more recently bred cultivars outyielded older ones (Dost *et al*. 1994).

HYBRID VERSUS VARIETIES:

Local maize and millet are dual purpose crops that are extensively grown in North Pakistan. Multicut hybrid sorghum could ensure maximum tonnage of green as well as DM well distributed throughout the summer growing period.

Overall hybrid sorghums provided four cuttings in Gilgit and Chilas and two in Skardu and Khaiber. At all the locations, all hybrids produced two to three times more green fodder and DM yields well distributed over the entire growing period as traditional local maize and millet cultivars. Due to higher temperatures in Gilgit and Chilas, maximum forage yields were recorded as compared to Skardu and Khaiber.

CONCLUSIONS

It was observed that the multi-cut hybrid sorghums which were scarcely known in the area produced 100-125 tonnes/ha green fodder yields as compared to 25-30 tonnes/ha fodder yields by local maize. The improved varieties of maize were superior in grain, stover, and green fodder yields as compared to local landraces. However, improved varieties were 20 to 30 days late in grain maturity. Also the improved oats and lucerne varieties produced two to three times greater yields than local varieties.

The improved berseem clover varieties produced 132-140 tonnes/ha green fodder yields in six cuts as compared to 80-85 tonnes/ha by shaftal clover in three cuts. Although there is no tradition of applying chemical fertilizers to the forage crops in the region, maximum forage yields were obtained through application of 150-75 N-P kg/ha at most sites. However, increased use of fertilizer could not be justified in many instances for economic and environmental reasons.

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