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Influence of intercropping on soil conservation, forage quality and control of pest

Foruzan Mir, * Maryam Shahriari, Elham Rastine, Zohre Zoraghi

M.Sc. student, Department of Agronomy, Islamic Azad University, Zahedan Branch, Zahedan, Iran

Abstract
Intercropping can be defined as the growth of two or more crops in the same space at the same time. This however differs from one region or zone to the other to confirm with the culture of the people. Several types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been described. The degree of spatial and temporal overlap in the component crops can vary somewhat, but both requirements must be met for a cropping system to be an intercrop. Intercropping has been reported to have yield advantage over sole cropping. These advantages can occur as a result of complementary use of growth resources such as nutrients, water and light by the component crops. Intercropping with legumes is an excellent practice for controlling soil erosion and sustaining crop production.

Keywords: Yield Advantage, LCI, plant diseases

Introduction
Intercropping
A cropping system is an aspect of farming system or agricultural production system which consists of one or more enterprises, or business activities in which sets of resources and inputs are uniquely managed by the farmer in the production of one or more commodities to satisfy human needs for food, fibre, various products, monetary income and other objectives (Okigbo, 1982). Intercropping can be defined as the growth of two or more crops in the same space at the same time (Andrews & Kassam 1976) [2, 3]. This however differs from one region or zone to the other to confirm with the culture of the people. Intercropping is the growing of two or more crops in proximity to promote interaction between them. In line with this definition, Wahua (1982) [36], Ikeorgu (1983) [20], Okigbo (1978) explained that intercropping is the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include their vegetative stage. Further to this definition, Gomez and Gomez (1986) [18], stated that where the overlap in time is too small for example only four weeks out of a growing season of 3-4 months, the term relay crop is used. This technology may enable the intensification of a farming system, leading to increased general productivity and biodiversity in the intercropped fields as compared to monocultures of the individual intercropped species (Vandermeer 1989) [35]. Sequential cropping, which is the growing of individual crop in sequence during one growing season on the same piece of land and intercropping, are the two basic principles of multiple cropping (Ruthenberg, 1971, Andrew and Kassam, 1975) [2, 3]. They noted that, Agro-silviculture i.e. the growing of arable crop mixtures involving the intercropping of arable crops mainly is among the three broad areas of intercropping. Intercropping is a common feature of agriculture in the tropical Africa as well as in the Asian and American tropics (Papendick *et al*. 1976, Okigbo 1978, Kurt 1984 and Dalrymple 1971) [30, 31, 11]. Specific intercropping systems have developed over the centuries in the different regions and they are closely adapted to the prevailing ecological and socio-economic conditions. Kurt (1984) explained that intercropping system differs frequently from one area to another with changes in soil and local climate while social and cultural conditions may superimpose on the ecological and economic zones. Thus, as regions and ethnic groups differ in their food preferences, so also do they differ in their cropping system Lagemann (1977) [23]. Observed that the increasing demand for cassava in the densely populated area of southern Nigeria combined with migration of the active male population to urban areas, has caused a decline in yam cultivation in favour of cassava. He stressed that. The population pressure in southeastern Nigeria has also led to an intensification of intercropping in order to increase the production per unit area. In general, there is a high indication in the importance of intercropping since it has for some time now become government policy to increase production by improving intercropping systems (Kurt, 1984).

Fig 1: Maize intercropped with red amaranth

Types of intercropping
Several types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been described (Andrews and Kassam, 1976) [2, 3]. The degree of spatial and temporal overlap in the component crops can vary somewhat, but both requirements must be met for a cropping system to be an intercrop. Thus, there are several different modes of

intercropping, ranging from regular arrangements of the component crops to cases where the different the component crops are intermingled. In mixed intercropping, the plants are totally mixed in the available space without arrangement in distinct rows, whereas in alternate-row intercropping, two or more plant species are cultivated in separate alternate rows. Another option is that of within-row intercropping, where the component crops are planted simultaneously within the same row in varying seeding ratios.

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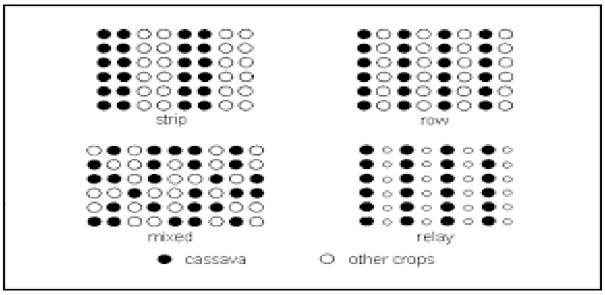

Fig 2: Types of intercropping

With strip intercropping, several rows of a plant species are alternated with several rows of another plant species intercropping also uses the practice of sowing a fast-growing crop with a slow-growing crop, so that the first crop is harvested before the second crop starts to mature. This practice requires some kind of temporal separation, e.g. different planting dates of the component crops so that the differential influence of weather and in particular temperature on component crop growth can be modified (Midmore, 1993) [28]. Further temporal separation is found in relay intercropping, where the second crop is sown during the growth, often near the onset of reproductive development or fruiting of the first crop, so that the first crop is harvested to make room for the full development of the second crop (Andrews and Kassam, 1976) [2, 3].

Fig 3: Mixed cultivation rubber tree with pineapple plantation in east of Thailand

Yield Advantage

Intercropping has been reported to have yield advantage over sole cropping. These advantages can occur as a result of complementary use of growth resources such as nutrients, water and light by the component crops (Enyi, 1973) [14]. The yield advantage may be in terms of higher yield or higher net income. He further explained that the yield can be quantified in terms of dry matter production, grain or root yields, nutrient uptake, energy or protein production and market value. According to Kurt (1984) and Gomez and Gomez (1986) [18]. The yield advantage is measured using land equivalent ratio (LER) or Relative yield totals (RYT). LER is defined as the relative land area under sole crop that is required to produce the yield achieved by intercropping at the same management level. While RYT is the sum of the ratios obtained from the relative yields (intercropping yields divided by respective sole crop yields) of the component crops in a mixture using the above calculations, yield advantage have been reported for cassava/maize and cassava/beans mixtures (CIAT 1979). According to Ikeorgu *et al*. (1983) [20], cassava/maize intercrop gives higher amount of calories per hectare of land than the pure stands. Also, land equivalent ratio of 1.71 has been reported for cassava/maize intercrop (CATIE, 1977) [7].

Stable yield

Another major advantage of intercropping is yield stability. That means a reliable food production over years that provides a high income for the farmer and enhances diversity of farm products (Rao *et al*., 1979). Gomez and Gomez (1986) [18]. Felt that intercropping does not only enhance diversity of farm products but also provides insurance against crop failure. They reported that with diversified crops, intercropping stabilizes yield through the principle of compensation. They explained that when one crop component suffers from pests, diseases, draught etc, the loss of this crop is compensated at least partially by the other component crop(s) since there is now less competition for growth resources, and stated that there would be no compensation if it were to be only a sole crop system.

Pest

Intercropping can play a significant role in integrated pest management. There are many cases where pests and especially weeds are suppressed by certain crop combinations like maize/soybean, maize/black gram, maize/velvet bean (Chaud and Sharma, 1977) [8]. They reported that in all the crop combinations there were pest (stem borer) reduction in all intercropping involving maize and another crop when compared to maize grown sole. According to Moreno (1979) [29]. Intercropping cassava and maize significantly delayed the onset of the cassava scab (Spaceloma spp) epidemic. Also, when cassava is planted in association with maize and common bean, there is less rust (Uromyces manihotis) on cassava. Arene (1976) [4]. And Ene (1977) [13]. reported that there was significant reduction of cassava bacteria blight (CBB) (Xanthomonas manihotis) by intercropping with maize, melon or other crops in Nigeria. They concluded that this reduction in CBB could be ascribed to the earlier and better soil cover provided by the intercrops, which at least to a significant level prevented splashing of the bacteria from the soil onto cassava leaves and stems. Wolfe (2000) [37] reported that farmers in Yemen province of China under the direction of international team of scientists made some simple changes in their rice production methods. They changed from planting their typically pure stand of single rice variety to planting a mixture of two different rice varieties. This technique helped in reducing blast disease and the farmers were able to abandon using chemical fungicides, which they had been using.

Controlling plant diseases

Intercropping can be advantageous for controlling plant diseases such as common bacterial blight and fungal rust (Boudreau & Mundt 1992; Fininsa 1996) [5, 15]. In organic field trials, a diseasereduction has been observed in intercrops of barley (*Hordeum vulgare* L.) with pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.) and lupin (Lupinus sp.). Intercropping pea with barley reduced the level of ascochyta blight (Mycosphaerella pinodes) in the peas, and the levels of net blotch (*Pyrenophora teres*), rust (*Puccinia recondita*) and powdery mildew (*Blumeria graminis* f.sp. hordei) were reduced on the barley plants in every intercrop as compared to the barley monoculture (Kinane & Lyngkjaer 2002) [22].

Legume-cereal intercropping (LCI)

In the past, legume-cereal intercropping (LCI) was a common part of the crop rotations on arable land in the Czech Republic (CR) (Šarapatka *et al*. 2009) [34]. Currently, however, LCI is not used to a great extent in the CR. This is generally due to agricultural intensification, when the benefits of LCI are outcompeted by cheap chemical inputs of fertilizers, pesticides and imported concentrates commonly based on cheap soy proteins. Organic farming systems are based on four basic principles of health, ecology, fairness and care (IFOAM 2007) [19]. The utilisation of local resources, and closed nutrient cycles aiming at self-sufficiency at a farm and district level, are logical consequences of the ecology principle. Hence, organic farmers aim at an increased production of protein and cereal crops to increase their self-sufficiency with animal fodder. To support the adaptation of LCI in organic farming systems, it is necessary to test relevant intercrops under organic growing conditions. Further, it is important to record practical experience with LCI at the farm level with the machinery normally used. It is also important to find suitable combinations of crops and varieties, and their optimal ratio in the seed mixture. The main objective of this paper is to present results of growing monocultures and intercrops of peas and spring cereals under Czech conditions. This may support an expansion of legume cereal intercropping, to ensure a larger diversity in the crop rotations on arable land in the CR, especially in organic farming systems. Thereby, it may help Czech organic farmers to become more self-sufficient with fodder for their animals. Yield levels of green matter and grains will be presented and discussed.

Soil conservation

Intercropping with legumes is an excellent practice for controlling soil erosion and sustaining crop production (El-Swaify *et al*., 1988) [12]. Where rainfall amount is excessive, cropping management systems that leave the soil bare for great part of the season may permit excessive soil erosion and runoff, eventually resulting in infertile soils with poor characteristics for crop production. Moreover, deep roots penetrate far into the soil breaking up hardpans and use moisture and nutrients from deeper down in the soil. Shallow roots bind the soil at the surface and thereby help to reduce erosion. Also, shallow roots help to aerate the soil. Reduced runoff and soil loss were observed in intercrops of legumes with cassava (El-Swaify *et al*., 1988) [12]. In another experiment it was observed that although soil erosion was greater with forage legume intercropping than with cassava sole cropping in the first cropping period, once they were well established and uniformly distributed, the undersown legumes controlled soil erosion effectively (Leihner *et al*., 1996) [24]. Similarly, sorghum-cowpea intercropping reduced runoff by 20-30% compared with sorghum sole crop and by 45-55% compared with cowpea monoculture (Zougmore *et al*., 2000) [38]. Moreover, soil loss was reduced with intercropping by more than 50% compared with sorghum and cowpea monocultures.

Improvement of forage quality

Combining the growth of cereal forages with other crops capable of increasing the protein content of the ration has great nutritional and financial value. Combinations of cereals with legumes are seen as one way of achieving this goal. Intercropping cereals with legumes and other fodder crops to provide forage for ensiling offers one method for increasing home-grown protein sources. Most patterns of intercropping corn with soybean produced more forage than sole crops compared at the same yield ratio of corn-soybean as in the intercrop harvested mixture (Putnam *et al*., 1986) [32]. Moreover, increases in crude protein content by 11-51% were recorded for the various intercrop treatments over corn sole crop. Intercropping field beans with wheat improved forage dry matter and percentage of dry matter compared with bean sole crop and also enhanced crude protein, neutral detergent fibre content, and water-soluble carbohydrates compared with beans and wheat sole crops (Ghanbari-Bonjar and Lee, 2002; Lithourgidis and Dordas, 2010) [17, 26].

Fig 4: Relay intercrpping

Forage yield and quality can be enhanced by intercropping barley or oat with pea (Carr *et al*., 2004) [4]. Also, barley intercrops with Austrian winter pea (Pisum sativum ssp. arvense) resulted in values of Land Equivalent Ratio ranging from 1.05 to 1.24 on a biomass basis and from 1.05 to 1.26 on a protein basis indicating a production advantage of intercropping (Chen *et al*., 2004) [9]. Intercropping corn with legumes was far more effective than corn monocrop to produce higher dry matter yield and roughage for silage with better quality (Geren *et al*., 2008) [16].

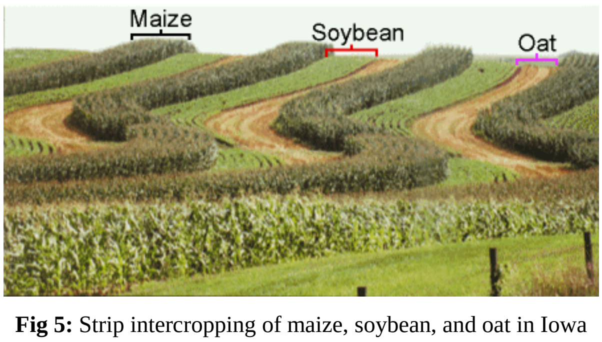

Fig 5: Strip intercropping of maize, soybean, and oat in Iowa

Common vetch intercrops with barley or winter wheat produced higher dry matter than sole common vetch and the intercrop of common vetch with barley at a seeding ratio 65:35 gave higher forage quality than other intercrops tested (Lithourgidis *et al*., 2007) [25]. Also, intercropping common bean with corn in two row-replacements improved silage yield and protein content of forage compared with sole crops (Lithourgidis *et al*., 2008) [27]. The crude protein yield, dry matter yield, and ash content of maize forage increased by intercropping with legumes compared with maize monoculture (Javanmard *et al*., 2009) [21]. Furthermore, intercropping legumes with maize significantly reduced neutral detergent fibre and acid detergent fibre content, increasing digestibility of the forage. It is evident from the above that intercrops of maize with legumes can substantially increase forage quantity and quality and decrease the requirements for protein supplements compared with maize sole crops (Javanmard *et al*., 2009) [21].

Fig 6: Rows Sweetpotato - between 1 row Maize

Maize and cowpea intercrops gave higher total forage dry matter digestibility han maize or cowpea sole crops and led to increased forage quality (crude protein and dry matter digestibility concentration) than maize monoculture and higher water-soluble carbohydrate concentrations than sole cowpea (Dahmardeh *et al*., 2009) [10].

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