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Evaluation of Agrobiodiversity and its Effects on the Sustainability of a Wheat-Cotton Cropping System in Khorassan

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Abstract

Biodiversity, which is a necessity of sustainable agriculture, can provide species that may act as natural enemies for biological control or genes for increasing crop resistance to biotic and abiotic stresses. The improvement of biodiversity by introducing crop species which have functions similar to off-farm inputs, reduces an agroecosystem's dependency and increases its self-sufficiency and sustainability. In order to evaluate the agrobiodiversity of a wheat-cotton cropping system and its effects on ecological sustainability, a survey was conducted in Khorassan province (eastern Iran). Agrobiodiversity indicators were the growing of other crops than wheat and cotton, planting forage legumes, green manure, livestock presence and diversity in the farm. The data were collected from Neyshabour, Bardaskan and Ferdows using 518 questionnaires. Results showed that only 7.9 and 1.4 percent of farmers grow forage legumes and green manure, respectively; 78 percent of farmers grow at least one other crop than wheat and cotton while 47.5 percent of farmers have one or more kinds of livestock in their farms which are mainly considered for family consumption. Results also proved a significant correlation between all agrobiodiversity indicators with ecological sustainability in this cropping system.

Keywords: agrobiodiversity, sustainability, forage legumes, livestock.

ارزیابی تنوع زیستی کشاورزی و اثرات آن بر پایداری یک سامانه کشاورزی گندم ـ پنبه در خراسان

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چکیده

تنوع زیستی که یکی از ضرورت‌های کشاورزی پایدار به شمار می‌رود، قادر به تامین گونه‌هایی است که می‌توانند کارکردهای گوناگونی در کشت‌بوم مانند تأمین دشمن طبیعی برای کنترل زیستی یا ژن‌های مسئول افزایش مقاومت گیاهان زراعی به تنش‌های زنده و غیرزنده داشته باشند. بهبود تنوع زیستی با وارد کردن گونه‌های زراعی که کارکردهایی مشابه نهاده‌های برون مزرعه‌ای دارند، وابستگی کشت‌بوم را کاهش و خوداتکایی و پایداری آن را افزایش می‌دهد. به منظور ارزیابی تنوع زیستی کشاورزی یک سامانهٔ کشاورزی با تناوب گندم ـ پنبه و اثرات آن بر پایداری بوم‌شناختی، مطالعه‌ای در سال ۱۳۸۳ در استان خراسان به انجام رسید. سنجه‌های کشاورزی زیستی شامل کشت گیاهان زراعی دیگر (غیر از گندم و پنبه)، کشت بقولات علوفه‌ای، کاربرد کود سبز و حضور و تنوع دام در کشت‌بوم بود. داده‌ها با استفاده از ۵۱۸ پرسش‌نامه از شهرستان‌های نیشابور، بردسکن و فردوس جمع آوری گردید. نتایج نشان داد فقط ۷/۹ و ۱/۴ درصد کشاورزان به ترتیب از بقولات علوفه‌ای و کود سبز در کشت‌بوم‌های خود استفاده می کنند. ۷۸ درصد کشاورزان حداقل یک گونه زراعی دیگر غیر از گندم و پنبه کشت می کردند. ۴۷/۵ درصد کشاورزان از یک نوع یا بیشتر دام در همبستگی مثبت معنی‌دار بین سنجه‌های تنوع زیستی کشاورزی و پایداری بوم‌شناختی سامانه‌های کشاورزی مورد مطالعه بود.

کلیدواژه‌ها: تنوع زیستی کشاورزی، پایداری، بقولات علوفه‌ای، دام.

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Introduction

Biodiversity, defined as genetic, species and ecosystem diversity and their ecological interactions (Duelli, 1997), is a necessary precondition for achieving sustainable agriculture. Biodiversity provides the sustainable balance and equilibrium in agroecosystems. For example, it can provide species that can act as natural enemies for biological control or genes for increasing crop resistance to biotic and abiotic stresses. Intensive and continuous changes in agriculture during last century have resulted in biodiversity losses in both natural and agricultural ecosystems. In natural ecosystems, the widespread application of agrochemicals in agroecosystems in form of fertilizers and pesticides has led to a decrease in the diversity of fauna and flora. On the other hand, the biodiversity of agroecosystems has decreased because of the rapid development of intensive farming and monoculture. Therefore, improvement of agrobiodiversity (biodiversity in farming systems) by introducing crop species which have functions similar to off-farm inputs, reduces agroecosystem dependency and increases its self-sufficiency and sustainability. Using legumes in crop rotation results in nitrogen fixation and a reduction in N fertilizer application. Legumes are rich in protein and can biologically fix the nitrogen through symbiosis with rhizobium bacteria (Sengul, 2003). The growth patterns of legumes and cereals are different; these include the extraction of water and nutrients from a deep profile of soil in legumes versus a shallow profile in cereal root systems or the horizontal leaves in legumes versus narrow leaves in cereals. As a result, inter-species competition between them is minimized and growing them in cereal-based cropping systems (both monoculture and intercropping) reduces off-farm input applications and also produces remarkable yield (Caballero, 1993). Green manure has long been known to improve soil structure and health and protect it from erosion during the period between two main crops in which soil is bared (Biederbeck *et al.*, 1998; Mitchell *et al.*, 1999 and Stopes *et al.*, 1996) and thereby increases agroecosystem sustainability.

There are several reports on the positive effects of agrobiodiversity measures on agroecosystem health and sustainability. Torknezhad *et al.* (1999) reported that the mean annual nitrogen fixation rate of annual medics (*Medicago* sp.) in Iran reached 103 kg/ha. Due to this fact and to forage production limitations in Iran, introducing this legume in crop rotation will help reduce fertilizer application and increase the sustainability of farming systems. Biederbeck *et al.* (1998) showed that green manure improved soil characteristics such as nitrogen and carbon mineralization, aggregate stability and organic matter content. The results of Mubarik (1999) also indicated that green manure improved soil characteristics and increased rice yield. Livestock presence in the farming systems can increase the farm production and income and reduce poverty (De Koijer *et al.*, 1995). This is especially important in smallholder farming systems in Asia, because the livestock is counted as capital in these agroecosystems and enhances its economic viability (Devendra and Thomas, 2002). Livestock has an extra importance in arid and semi-arid areas where environmental low stability always threatens crop yield (Devendra, 2000). Furthermore, the presence of livestock in the agroecosystem can reduce the need for chemical fertilizers, because farmyard manure can be applied as an alternative for chemical inputs.

The objective of present study is to evaluate the agrobiodiversity in a wheat-cotton cropping system in Khorassan and its effects on ecological sustainability of the system.

Materials and Methods

The study data were gathered from three towns (Neyshabour, Bardaskan and Ferdows) in Khorassan Province, northeastern Iran, by means of 518 questionnaires. The questionnaires passed the validity test and were filled during interview with farmers in the wheat-cotton agroecosystems. Wheat and cotton are of most important crops in Iran, while wheat is the most strategic agricultural commodity of the country. Cotton also plays a main role in cropping systems of Iran since two million people are involved in the production, processing and distribution of cotton and related industries and it is now planting in 14 provinces of Iran (Kelantari and Mirgowhar, 2002). Agrobiodiversity indicators consist of growing other crops than wheat and cotton, planting forage legumes, green manure, livestock presence and diversity on the farm. In addition, other indicators are classified into a further seven groups (socio-economic, crop production, chemical fertilizer and pesticides, crop residue management, water and irrigation, tillage and machinery and weed management indicators) to develop a sustainability index. The weighting sum method (Andreoli and Tellarini, 2000) was used to calculate the sustainability of the cropping system (Mahdavi Damghani *et al.*, 2006). Each indicator had a score ranging from zero to a maximum value. The highest and lowest scores represented the most favorable and the worst conditions, respectively. For example, the scoring indicator for crop species diversity when planting no other crop than wheat and cotton had zero, when planting one crop had 1, with two crops had 3 and when planting more than two crops had a score 0f 5. After quantifying system sustainability, the relationship between agrobiodiversity and the sustainability of the cropping system was determined.

Results and Discussion

A) Crop Species Diversity

Crop species diversity of the wheat-cotton cropping system is shown in Table 1. 78 percent of farmers grow other crops than wheat and cotton, of whom 18 percent grow one, 31 percent grow two and 29 percent of them grow more than two other crops (Figure 1). There was a significant positive correlation between crop species diversity with sustainability (Table 2) and wheat yield (Table 3). On average, each farmer grows 1.8 other crops other than wheat and cotton in the studied area. 7.9 percent of farmers introduce forage legumes into their crop rotation program in which, in Bardaskan county, only one percent of them grow forage legumes. Climatic conditions can be counted as the main limiting factor in applying forage legumes in these cropping systems, because forage legumes generally have high water demand (Caballero, 1993) and Khorassan Province is located in an arid environment. For example, the annual rainfalls of Bardaskan and Ferdows in the year studied (2004) were 150 and 120 mm, respectively. Furthermore, higher economic intensives for growing cotton appear to be another limiting factor in use of forage legumes by farmers. This is true also for green manure, so that only zero, 1 and 3 percent of farmers in Bardaskan, Neyshabour and Ferdows, respectively, apply green manure to their farms. Correlation analysis showed a positive correlation between forage legume plantation

Table 1- Frequency (%) of agrobiodiversity indicators in the studied area. Crop diversity means the percentage of farmers who grow other crops than wheat and cotton.

County	Agrobiodiversity indicators				
	FLG	GMA	CD	MCC	LPF
Neyshabour (350)	8	1	71	1.7	47
Bardaskan (68)	1	0	91	2.1	23
Ferdows (100)	13	3	93	2.2	67
Average	**7.9**	**1.4**	**78.0**	**1.8**	**47.5**

FLG: forage legume growing, GMA: green manure application, CD: crop diversity, MCC: mean number of cultivated crops (by each farmer, not presented by percentage) and LPF: livestock presence in the farm. Numbers in the parenthesis indicate the number of studied farms in each county.

Table 2-Correlation coefficient of agrobiodiversity indicators with sustainability index of cropping systems in the studied area.

	Agrobiodiversity indicators				
	FLG	GMA	CD	LPF	LD
Correlation coefficient	0.228**	0.062	0.323**	0.265**	0.259**
No of samples	518	518	518	514	514

FLG: forage legume growing, GMA: green manure application, CD: crop diversity, LPF: livestock presence in the farm and LD: livestock diversity.

** : significant at p< 0.01

Table 3- Correlation coefficient of agrobiodiversity indicators with wheat and cotton yield of cropping systems in the studied area.

	Agrobiodiversity indicators									
	FLG		GMA		CD		LPF		LD	
	Wheat	Cotton	Wheat	Cotton	Wheat	Cotton	Wheat	Cotton	Wheat	Cotton
Correlation coefficient	0.072	0.086	-0.055	-0.065	0.123**	0.069	-0.108*	0.080	-0.032	0.158**
No of samples	516	497	516	497	516	497	513	495	513	416

FLG: forage legume growing, GMA: green manure application, CD: crop diversity, LPF: livestock presence in the farm and LD: livestock diversity.

** : Significant at p<0.01

* : Significant at p<0.05

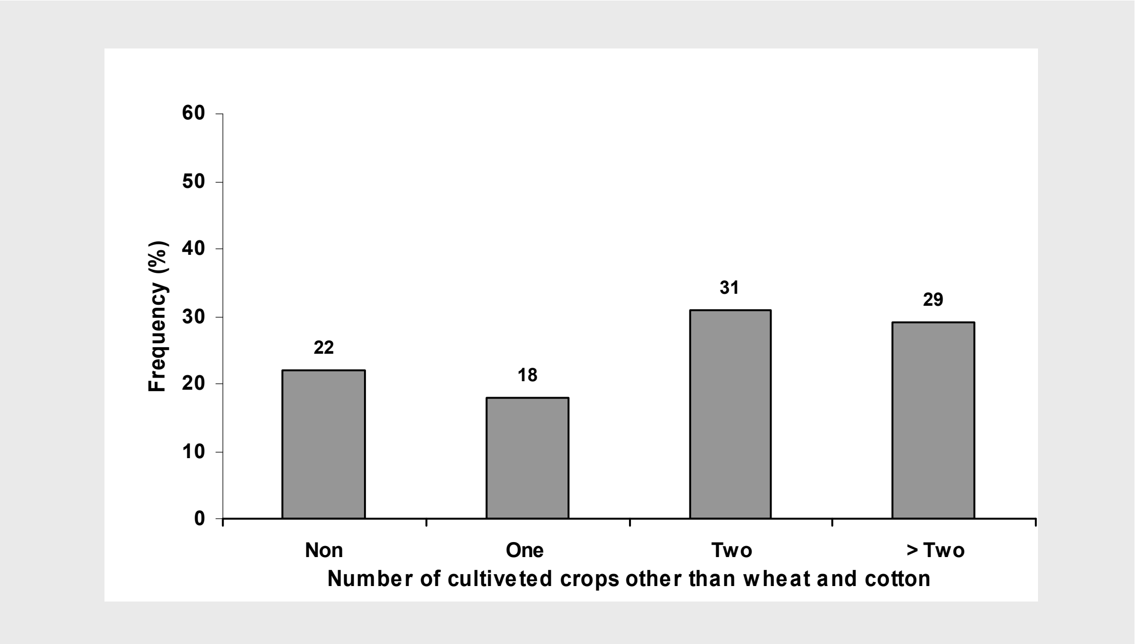

Figure 1-Crop species diversity in the wheat-cotton cropping system studied. (‘None’ means farmer grows only wheat and cotton in the farming system).

and sustainability of the system (Table 2). Torknezhad *et al.* (1999) and Caballero (1993) reported the positive effect of growing legumes on the sustainability of agroecosystems. In this study, however, the relationship between growing green manure and sustainability was not significant.

B) Livestock Diversity

Livestock are present in about half of the cropping systems (Figure 2). The highest and lowest measures were respectively for Ferdows (67 percent) and Bardaskan (23 percent). Data on livestock diversity showed that, on most farms, there is only one kind of livestock and only in one percent of them are there more than two livestock species (Table 1). Although nearly half of all farms have livestock, according to low livestock milk and meat production (data not shown) it seems that livestock are mainly for the farmers' family consumption and it is not reasonable to include them as a part of production system. However, the positive correlation between livestock presence and diversity with sustainability index in this study indicates their role in sustainability of farming systems. Caballero (1993) argued that the small size of farms is a main constraint for introducing livestock and growing forage crops in farming systems. In these smallholder systems, there is not enough land to grow forages and so there is no possibility of introducing livestock in the agricultural system. Results of the study showed more than 79 percent of farms were two hectare or less (Figure 3). Animal husbandry in such small farms is impossible and so there is no need to introduce forage crops as a part of crop rotation program of the farming system.

Another important factor limiting the use of forage legumes and green manure in these cropping systems is a deficiency or lack of information by farmers about forage legumes and green manure's ecological functions as well as their agronomic, economic and environmental benefits in agroecosystems. In addition, not introducing species or cultivars of forage legumes and green manure adapted to environmental condition of Iran is another constraint in utilization of these crops in these farming systems.

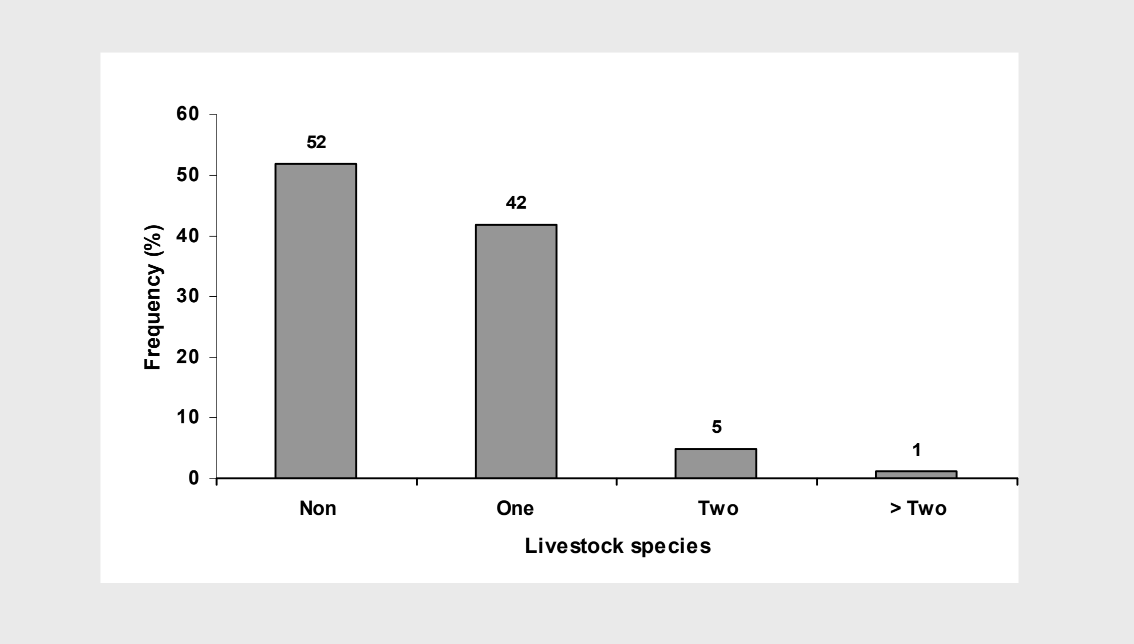

Figure 2- Livestock species diversity in the wheat-cotton cropping system ('None' means that there is not any livestock in the farm).

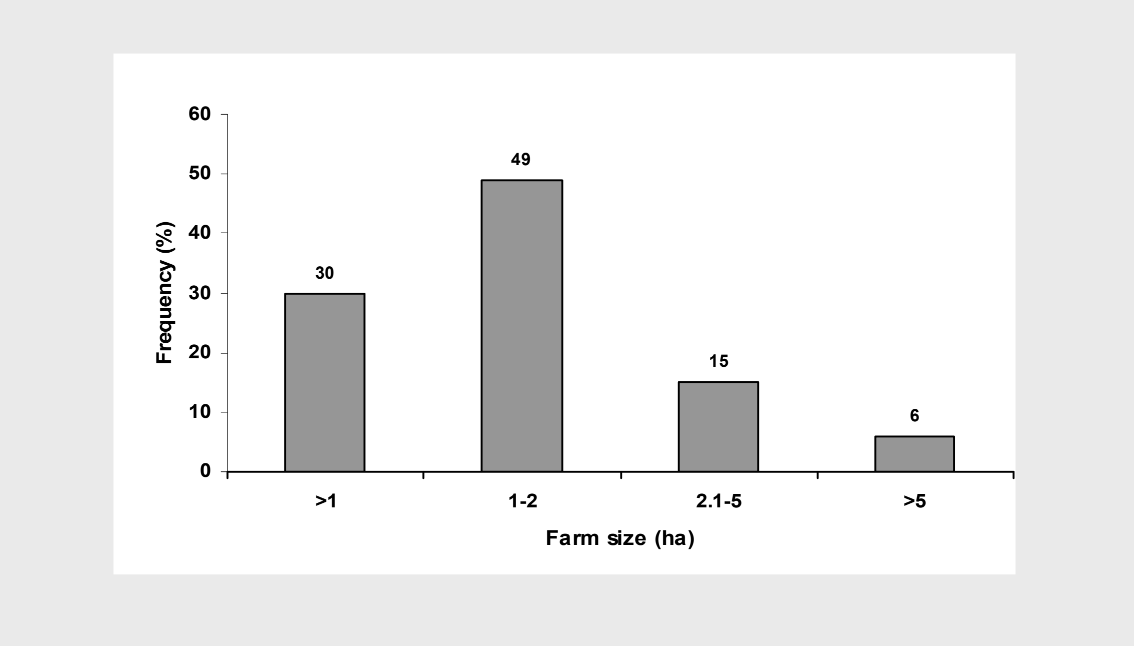

Figure 3- Farm size in the wheat-cotton cropping systems studied.

Conclusion

Improving the sustainability of wheat-cotton cropping systems through enhancing agrobiodiversity in Iran requires a multidimensional struggle by farmers, researchers and policy-makers. First, researchers should conduct experiments in order to determine suitable plant species and cultivars for introducing to these farming systems as forage legume or green manure. These crops should have a low water demand and high water use efficiency as well as tolerating environmental stresses like salinity and high temperature. They, meanwhile, should be economically competitive with crops like cotton, sugar beet and cereals which are the cash crops of the studied area. Second, education and extension attempts should be undertaken to make farmers familiar with several benefits of forage legumes and green manure and agronomic practices for their production. Finally, policy-makers should foster a positive atmosphere by supporting smallholder farmers in introducing new crops and animal husbandry through financial support, providing machinery and education as well as subsidies to pioneer farmers.

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