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Farmer's knowledge and perceptions about multipurpose trees and tree intercropping systems in post-independence private farming systems in Uzbekistan

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ABSTRACT

A wealth of literature confirms that tree intercropping systems may contribute to the welfare and livelihoods of farmers. Given the private type of farm management in Uzbekistan knowledge about the level of awareness and attitude of land users practicing tree-intercropping systems is of utmost value before any recommendations should be made. A survey among 35 farm households in Khorezm compiled quantitative (width and length, size of plot, stand density, age, species composition, type of crops) and qualitative data on farmers' knowledge, reasoning and understanding of the systems practiced. Farmers prioritized fruit over woody species. The abundance of young trees indicated the only recent growing interest of land users in tree planting after which were triggered by land reforms. The diversity and the intensity of land use evidenced that the cropping schemes were influenced by the tree age, but even the older sites included combinations typical for younger gardens. Farmers exposed superficial knowledge on the management of tree intercropping systems, which was complied with knowledge generated by researchers. Only a reduced number of aspects of this collective and commonly shared knowledge were mentioned. Despite the variation of tree-crop combinations, farmers deliberately selected a land use, which was guided chiefly by economic and financial reasons thus compromising between a technical optimization of the tree-intercropping system and increasing the economic efficiency of such systems. It is therefore suggested that the national administration in Uzbekistan should initiate training and education of farmers and gardeners to improve their cultural practices and gain the potential benefits of tree intercropping systems.

АННОТАЦИЯ (RUSSIAN ABSTRACT)

Множество литературных источников представляет доказательства того, что системы совмещенных посадок древесных пород с различными культурами выгодны во многих отношениях для фермеров. Однако, с учетом частного типа хозяйствования в Узбекистане для разработок каких-либо рекомендаций большую ценность имеют данные об информированности и отношении самих землепользователей, практикующих такие агролесные системы. В ходе опроса 35 хозяйств в Хорезме были собраны количественные (ширина и длина, размер участков, густота насаждений, возраст, породный состав, виды культур) и качественные данные по знаниям фермеров, их мотивации и понимании указанных

систем. Опрошенные фермеры предпочитали древесным породам фруктовые деревья. Изобилие молодых деревьев показало недавно возросший интерес землепользователей к древесным насаждениям, что, очевидно, связано с недавними земельными реформами. Разнообразие и интенсификация землепользования свидетельствует о том, что схемы посадок варьировались в зависимости от возраста древесных насаждений, но при этом участки с более взрослыми деревьями также содержали комбинации, типичные для молодых садов. Часть фермеров обладали поверхностными знаниями по управлению системами совмещенных посадок, частично совпадающими с научными знаниями. Было упомянуто всего лишь несколько аспектов таких собирательных и общеупотребительных знаний. Несмотря на варьирование комбинаций в совмещенных посадках, фермеры выбирают вид землепользования, в основном, руководствуясь экономическими и финансовыми мотивами, и, таким образом, находя компромисс между технической оптимизацией системы и возрастающей экономической эффективностью таких совмещенных систем. Следовательно, местной администрации следует организовывать тренинги и обучение фермеров и садоводов для усовершенствования их знаний и достижения потенциальных выгод агролесных систем.

PREFACE

Even smaller gardens where few trees and bushes are grown together with crops represent an ecological system. Their management appears to be more difficult than one may expect by the size of the plot and the sparse vegetation. Gardeners apply their diverse knowledge, generated and gained over many years, to plan the diversity of potential crops and decide what and when to crop, while considering social and economic aspects of land use. Such decisions depict the values and priorities of land users in the selection and management of crops and trees in tree intercropping systems.

Previous research on tree intercropping in Uzbekistan has primarily focused on the role of trees for protecting arable land from wind erosion and further land degradation. The National Action Program (NAP) from 1999 underscored the necessity to combat land degradation and desertification also by agroforestry-based systems which also was mentioned as a means to integrate trees in the agricultural landscape. Yet, the fact that such practices have to be aligned with socio-economic aspects was hardly mentioned. Given the agricultural reforms and the change in the land use situation from the previous

Soviet-type collective farm management to a private one, it is of utmost importance to know the attitude of the newly established private farmers and gardeners towards such practices before making any land-use recommendations. Consequently it is necessary to learn first about farmers' knowledge and appreciation of their environment, their management, practices and attitude towards such complex tree intercropping systems. In this way the newly emerged farming population in Uzbekistan could be supported in their quest to secure better livelihoods.

1 INTRODUCTION

Following independence in 1991, the rural population in Uzbekistan gained access to the land distributed by the government. The farmer in Uzbekistan forms now the basis of the agricultural production enterprises. When aiming at the introduction of improved land use systems, the participation of land users has become indispensable for research. In particular the improved understanding of perceptions and reasoning of the farming population regarding e.g. tree-crop systems needs to be understood. The interaction between the scientific community and the users of scientific results should be considerably improved in Uzbekistan to match results experienced elsewhere (Lamers et al. 2000). Since the management of tree and non-tree resources is a human activity, this in particular dictates to include social aspects in future research efforts in addition to technical and economic aspects.

During the ongoing gradual transition from the centralized, planned management to a market-oriented economy, a great number of land users (one cannot call them farmers yet) has appeared in Uzbekistan, yet the management knowledge, experience and background on agriculture to run private farms is limited (Wall 2006). Farmers were hardly prepared for the new challenges and have insufficient knowledge to cope e.g. with soil salinity, deficient irrigation, shallow saline ground water, and advancing desertification, which have been experienced after independence also in other former republics of the Soviet Union (Lamers et al. 2000). About 24% of Uzbekistan's territory is affected by soil degradation (ICARDA 2007), mainly caused by human guided agricultural practices. Of this, about 13% have been severely degraded with no possible reclamation. Appropriate measures are needed to help farmers adapting to these conditions, mitigating the widespread and expanding land degradation and perhaps even reversing the present trends.

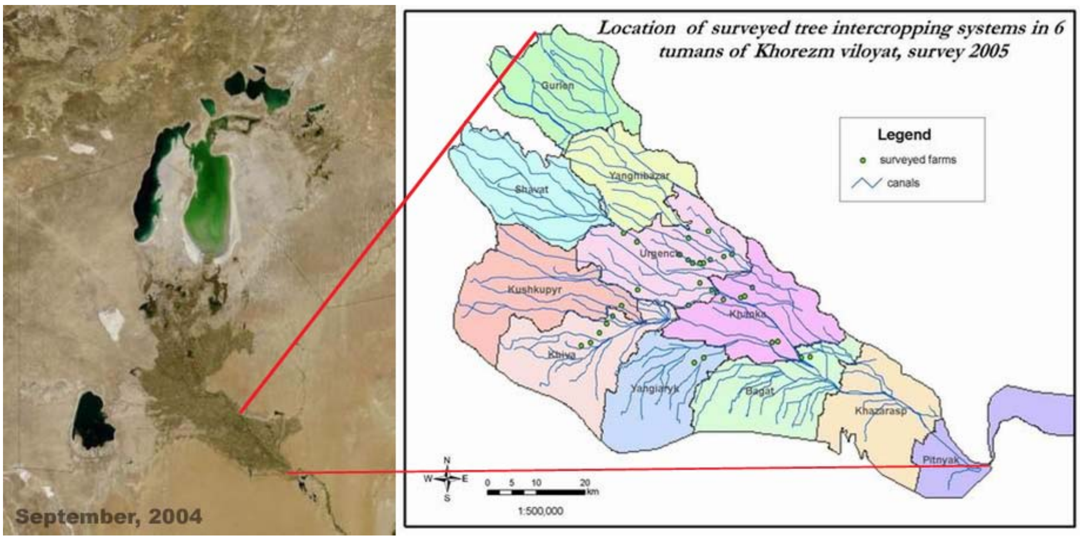
In 1999, the Republic of Uzbekistan launched its National Action Program (NAP) to combat land degradation and desertification in the country. Along with other measures the NAP proposed agroforestry-based systems to intensify the integration of trees in the agricultural landscape, e.g. to protect arable land from wind erosion and sand deposition. This decision was motivated by a worldwide recognition that agroforestry (AF) can play a significant role in sustainable development while providing the population with a wide variety of (by)-products. During the past 30 years, AF has progressed worldwide from a traditional practice to a science-based means of achieving key objectives in natural resources management and poverty alleviation (Garrity 2004). E.g. trees grown on farmers' lands may provide products that complement the whole-farm production, which is of value in particular for poor farmers and inhabitants of low-yield lands. But a good organization and viability of AF systems to a great extent depend on the interest, knowledge and concern of farmers in practicing agroforestry with a diversity of crops and trees.

Multipurpose tree intercropping systems are not new for the private farmers in Uzbekistan, but research in this area has barely started so that virtually everything remains to be done to develop a better blend between trees and crops. Very recent research has addressed the potential of several individual species for phyto-amelioration of degraded land, but did not include a farming system perspective (Khamzina et al. 2005a). Additional data was collected on various qualitative and quantitative properties of stem wood and fodder, and was later complemented by an investment analysis of small scale forest plantation (Lamers et al. forthcoming). Many reported aspects of trees common in Uzbekistan (e.g. Gintzburger et al. 2003; Walter and Breckle 1986), are comprehensive but did not really address the trees of interest for farmers. A recent attempt to make an inventory of trees and forests using the low altitude photography method was quite successful but merely focussed on the trees planted in line, tree plantations and the *tugai* forests and therefore did not include tree-crop systems as practiced by small scale farmers (Tupitsa et al. 2006). Consequently, this study complements these completed as well as the ongoing studies and is a first step in increasing the understanding of the technical and ecological knowledge as well as the socio-economic motivation of the landowners, which is indispensable to support producers in developing more viable tree intercropping systems. Although these systems have a high potential, they require a careful management to ensure that the potential benefits from both trees and crops can be obtained. This study therefore has three goals: it intends to (1) complement the previous tree mapping with a mapping of the diversity of the farmer managed tree-intercropping systems in Khorezm, located in the Northwest of Uzbekistan, which was used as a model region for all of the irrigated lowlands in the Aral Sea Basin; (2) capture the extent of knowledge, experience and motivation of land users of tree intercropping systems and how these affect their choice of integrating tree species into their production systems and in the landscape; and (3) - through in-depth studies on garden-based systems and tree shelterbelt systems - grasp the farmer's preferences and motives for the choice of the trees and crops for such tree intercropping systems.

2 MATERIALS AND METHODS

With the use of the Rapid Rural Appraisal methodology (Carruther and Chambers 1981; Hildebrand 1981; Hondale 1979) 35 private owners or land renters[1] in six tumans of the Khorezm Viloyat (Province, Figure 1) were surveyed from June through July 2005. Khorezm is located between 60.05 and 61.39 N and 41.13 and 42.02 E of the Greenwich meridian, and about 225 km south from the present shores of the Aral Sea.

Figure 1 The location of surveyed farm-based tree intercropping systems in 6 districts of Khorezm. Survey, 2005.



[1] Since 1998, three main farming systems are present in Khorezm: state farms (although there are only two of them left in the region out of a total of 124 in 2002), private farms (independent enterprises engaged in agricultural production on rented land), and *dehqon* farms cultivating household plots in lifelong hereditary possession.

A variety of methodological approaches ensured the representative selection of the survey locations. Based on an initial random sampling, with purposive and snowball sampling methods (Burton 2000) the final choice of these locations was realized. Once the first site was identified and the survey completed, whenever possible a distance of 2 kilometres (arbitrarily determined) was observed to select the next survey site. The presence of any trees planted in that encountered location was the main criterion to be included as an additional site.

Both quantitative and qualitative data were collected. Unstructured and semi-structured interviews were used for the collection of quantitative information. The questions and questionnaires were pre-tested. At each site, the width and length of each plot as well as the distance between the trees was measured to estimate the stand density accurately with a measuring tape. Each site was in addition described with key indicators such as the type of crops, the tree species and their age. The AF systems were analysed according to their specialization, function, arrangements, type of planting, density, age and composition of the multi-layered systems thus including the upper and under storey vegetation.

Based on the "key components" approach (Nair 1985), the AF systems in Khorezm could without exception be classified as "simultaneous systems" in which trees and crops or animals grow together at the same time on the same piece of land. Qualitative data on these key aspects was collected via in-depth interviews with land users and landowners with the objective to grasp their knowledge, their reasoning and degree of understanding of the systems practiced. Additional interview topics focused on the knowledge on environmental aspects of the tree-crop systems and its components.

Emphasis was given to the knowledge about the rooting depth of the crops and trees. Roots in general and fine roots in particular play an important role in ecosystem functioning (Smucker and Aiken 1992). Consequently, several locations were subjected to a more profound analysis and served as an additional means to assess the farmers' and gardeners' knowledge on possible competition between trees and crops grown together. These case studies focused on the perception about, and understanding of, the land users on crop tree interactions. But also on their motivation to grow trees, and the knowledge on tree properties and possible ecological functions of the upper storey vegetation. During analyses and consequent reporting, an attempt was made to present the findings of these case studies as a support for conclusions from the findings of the quantitative information collected.

Data was entered in the computer and checked for possible blanks. When necessary, revisits occurred. The preparation of the data for analyses included the coding of information, data entry and statistical processing using SPSS and Excel software. Furthermore, the data analysis included analytical induction methods through which the hypotheses were specified.

3 RESULTS

3.1 Characteristics of the AF systems

The combination of trees and crops. The surveyed production systems typically consisted of multi-layered tree intercropping plantations, which combined various agricultural crops, fruit and woody tree species (Table 1). The most frequently encountered tree intercropping system was also the most complex one, followed by one that combined several annual and biannual crops with fruit trees. The majority of the systems comprised trees plus crops only, and they could thus all be classified as simultaneous systems. A common practice, principally within all woody components, was to graze livestock after the harvest in June/July of cereals such as winter wheat.

The 35 surveyed farmers cultivated more than ten different tree-crop combinations. Fruit species were dominant; i.e. the majority of the gardens were orchards and the main farm production was horticultural. Three sites differed distinctly; one was a poplar plantation; the second included only woody species and associated wheat/sorghum, and the third was a mulberry plantation.

Species composition: The wood trees included in particular poplar species (*Populus nigra*, *Populus alba* L.) mixed with willow (*Salix* spp.) and Russian olive (*Elaeagnus angustifolia* L.) and elm (*Ulmus pumila*) trees. These trees were planted mainly along the field contours or formed the border with neighboring fields, plots or gardens. Trees such as *E. angustifolia* and common jujube (*Ziziphus jujuba* Mill) were included as ornamental trees inside the protecting borders, but their fruits were of minor importance and used as a supplement for food or medicine. Another fruit species such as mulberry (*Morus* spp.) was planted along with the wood species, but this procedure was introduced by former state forestry departments for intensifying sericulture. A diverse number of fruit species was recorded in the surveyed farms but the species were dominated by apple (*Malus* spp.), apricot (*Prunus armeniaca* L.) and pear (*Pyrus* spp.) trees.

Table 1. Occurrence (in number and frequency) and the ranking of the combinations of tree and crop species monitored in the farms surveyed (N=35), 2005.

No	Tree-crop combination	Occurrence		
		Number	Frequency (%)	Ranking
1	Fruit trees + forage crops	4	11.4	2
2	Fruit trees + vegetable crops	1	2.9	4
3	Fruit trees + forage crops + vegetable crops	1	2.9	4
4	Wood trees + forage crops	1	2.9	4
5	Fruit trees + agricultural crops + forage crops	1	2.9	4
6	Fruit trees + agricultural crops + forage crops + vegetable crops	2	5.7	3
7	Fruit trees + wood trees + agricultural crops + forage crops + vegetable crops	20	57.1	1
8	Fruit trees + wood trees + forage crops	1	2.9	4
9	Fruit trees + wood trees + forage crops + vegetable crops	1	2.9	4
10	Wood trees + agricultural crops + forage crops	1	2.9	4
11	Fruit trees + wood trees + commercial crops + vegetable crops	2	5.7	3
Total		35	100	

The vegetable plants on the surveyed fields included mainly tomatoes, potatoes, cucumbers, and cabbage varieties.

Arrangement and type: The observed tree stands were mostly alley plantings (Nair 1985), with trees planted in rows such as windbreaks, forest shelterbelts, hedgerows or contour plantings whilst crops were planted in between them were.

Age: The tree age ranged between 3-32 years (Table 2). The age of the woody and fruit tree stands did not always correspond, but in the group of fruits trees, younger trees with an age of 3-8 years old prevailed (57.1 %). Five-year old trees dominated with 20 %, pointing to a peak planting activity in the year 2000, five years prior to this study. Old and very old (>20 years) trees were less frequent, indicating that the practice of planting trees has gained momentum since approximately the 1980s.

Table 2. Occurrence (in number and frequency) of tree age at surveyed plantations (N=35), 2005.

Tree age	Number	Frequency %
3	1	2,9
4	4	11,4
5	7	20,0
6	3	8,6
7	3	8,6
8	2	5,7
Age group I	20	57.1
15	4	11,4
16	1	2,9
20	3	8,6
Age group II	8	23
25	3	8,6
27	1	2,9
28	1	2,9
29	1	2,9
32	1	2,9
Age group III	7	20
Total	35	100

Young systems with trees <10 years had the most diverse cropping patterns. Most frequent was the combination fruit trees/woody trees/food crops/forage crops/vegetables (No.7,Table 3), recorded at about 30% of the farms surveyed. Older plantations were less diverse, including combinations such as fruit trees/wood trees/agricultural crops/forage crops/vegetable crops (No.7) and fruit trees/forage crops (No. 1), each with 9 % (Table 1). *Tree density:* The tree density varied from 156 tree ha-1 to 1666 tree ha^{-1}. A frequently observed tree density was 200-500 trees ha^{-1} irrespective of tree species and age. The oldest tree stands (>20 years) showed the widest density variation, with a maximum recorded density of 600 trees ha^{-1}.

Table 3. Occurrence (in number) of tree intercropping systems according to tree age groups (N=35), 2005.

Tree age	No of tree crop combination (see Table 1)											Number of cases
	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	
1-10	-	1	-	1	1	-	12	1	1	1	2	20
11-20	1	-	1	-	-	-	6	-	-	-	-	8
>20	3	-	-	-	-	1	3	-	-	-	-	7
Total	4	1	1	1	1	1	21	1	1	1	2	35

Table 4. Tree stand density in surveyed farms (tree ha^{-1}), N=35, 2005.

Tree stand density ha^{-1}	*Malus spp.*	*Prunus armeniaca*	*Pyrus spp.*	*Prunus persica*	*Prunus cerasus*	*Cydonia spp.*	*Prunus domestica.*	*Morus alba*	Total
156-178	3	2	3	1	-	2	1	-	12
208-285	14	10	8	7	2	4	6	-	51
317-366	6	5	3	3	-	-	-	-	17
416-476	6	4	5	5	3	4	4	-	31
625	1	1	1	1	1	1	1	-	7
1111	-	-	-	-	-	-	-	1	1
1666	1	1	1	1	1	1	-	0	6
Total	31	23	21	18	7	12	12	1	125

Although the tree spacing varied with the fruit species planted, in most of the cases (51 out of 125), the distance between the various fruit species was equal for all fruit species planted. For determining the distance between trees farmers use as a rule of thumb whether or not the branches of neighbouring trees are touching each other. Farmers mentioned in particular that a wider spacing (for instance, 8x8m, 6x8m, or 7x7m) facilitates the use of agricultural equipment such as for soil tillage or the harvest of the inter-planted crops. Additionally, owners claimed that species such as apricot and apple were planted according to the recommended, conventional density, but all other species could be placed more densely.

Tree use: **Each tree species had its specific use and appreciation by the surveyed farmers and determined the choice of the perennials. A clear priority was given to fruit species, which were grown mainly for home consumption (ca. 52%), whereas the surplus was sold at local markets (**

Table 5). Few farmers produced fruits on a contractual basis. The use of species for both wood and fruit was the aim of 28.6% of the farmers interviewed, whereas the wood of poplar and willow species were used primarily for construction within the household. Few farmers grew trees for domestic consumption only.

Use	Number	Frequency (%)	Ranking
Sale/Consumption	18	51.4	1
Sale/Consumption and construction wood	10	28.6	2
Household use	2	5.7	3
Sale	1	2.9	4
Construction wood	1	2.9	4
Fodder (mulberry)	1	2.9	4
Household use and construction wood	1	2.9	4
Consumption /sale + charity	1	2.9	4

Table 5 Occurrence (in number and frequency) and ranking of tree use as stated by farmers (N=35), 2005.

Although the surveyed farmers expressed their desire to grow in particular multipurpose trees, which can produce both fruits and wood, when given the choice they named only few wood species and basically opted for fruit species. Farmers pursued, however, a dual purpose with the fruit trees. Primarily they anticipated the fruit production, but upon maturity of the trees and at declining fruit production, they started using the wood for construction and/or as fuel. In several cases farmers mentioned that apricot wood was suitable for carpenters. Although individual farmers also mentioned using trees as a livestock fodder, this was restricted to some species only, e.g. mulberry. Other tree leaves were used during springtime and only in the absence of alternative feed. One farmer sold and consumed fruits himself but also recurrently delivered part of them to the local children's home.

3.2 Sociological and ecological considerations

Crop-tree interactions: When expressing their opinions about tree-crop interactions, the surveyed farmers pointed at positive and negative aspects of growing trees and crops together. Farmers recognized for example the advantage of trees with regard to light, whereas possible losses were attributed to the competition for water, nutrients, and shade (Table 6), in which case as a remedy the woody trees were planted at a certain distance from the crop field.

Most of the surveyed farmers considered the combined planting as a means of weed control, where the trees were considered key in suppressing the germination and growth of weeds. Few farmers stated that the crop rotation underneath the trees is profitable for the latter.

Table 6. Occurrence (in number and frequency) and ranking of farmers' opinions about the tree-crop interaction (N=35), 2005.

Assessment of crop-tree interactions	Number	Frequency (%)	Ranking
Positive aspects			
Trees suppress the weed growth	16	45,7	1
Trees protect the crops from wind	14	40,0	2
Soil improvement	14	40,0	2
Tress keep the moisture in soil	9	25,7	3
Fruit trees attract bees	8	22,8	4
Trees are good for pest control	7	20,0	5
Common use of nutrients	4	11,4	6
The crop change is possible in inter-rows	3	8,6	7
Negative aspects			
Shading	34	97,1	1
Tree root development	14	40,0	2
Drying of trees	1	2,8	3

Soil improvement: The potential for soil improvement in tree-crop interactions was mentioned a few times (Table 6). Farmers claimed that an increase in soil quality was caused by the tree leaf litter, which would substitute even animal manure. According to the interviewees, the distribution of nutrients between crops and trees was another aspect of crop-tree interaction, which could be both equally or non-uniformly. About 23 % of the surveyed farmers stated that the combined planting of nectariferous tree species and crops on one plot and the diversity of fruit trees in the garden favoured apiculture. According to some land users, trees maintained the moisture in the soil and *E. angustifolia* was attributed even soil desalination properties.

Almost all farmers stated that trees occupied much more space above- and belowground than the crops and were dominating in the competition for space and light. Finally, one farmer explained about the incompatibility of trees in particular with winter wheat, since the latter could enhance the drying out of saplings.

Motivation for tree cultivation: Several questions addressed the level of understanding and reasoning of the farmers for planting trees (Table 7). Intensification of land use was given as the main reason for intercropping, with particular reference to irrigation and fertilization. The timing for these cultural practices was determined by the requirements of the annual rather than the perennial vegetation and geared to save time and other resources. As an important social factor it was underlined that vegetables, fruits and potatoes for a number of years would be excluded from the state order system and the usual imposed charity mechanisms to distribute at the expense of the producer the products grown. Among the ecological advantages of tree-crop integration only few farmers (6%) recognized the windbreak function of trees planted along the borders of their fields.

Attributed tree properties: Upon request, the interviewed farmers listed a number of properties they attributed to the trees. All farmers started with the oxygen and clean air production, which was associated with all trees. Based on observations that in early autumn the usual saline crust on the soil surface did not appear underneath *E. agnustofolia*, this species was accused of being salt extracting. Moreover, it was mentioned that this species could grow under any conditions and in any soil texture. No mention was made of drought or heat resistance of this species. Various tree species were characterized as water-loving, but nothing specific was said about the optimal planting density, species requirements for water and nutrients, as well as e.g. pruning techniques.

Table 7. Occurrence (in number and frequency) and ranking of the farmers' motives mentioned for the combined growing of tree species and crops (N=35), 2005.

Motive	Number	Frequency (%)	Ranking
Optimum land use	17	48,5	1
Optimum land use in an old garden	11	31,4	2
Optimum land use + concurrent tree/crop management	3	8,6	3
Optimum land use + old garden + concurrent tree/crop management	2	5,7	4
Windbreak + Optimum land use	2	5,7	5
Total	35	100	

Future tree choice: When asked to select those tree species, which farmers preferred planting on the available land when having a choice, virtually all interviewed mentioned fruit trees (Table 8).

The choice of woody species such as *Populus nigra* was motivated by income generation. Poplar and willow species were considered as multipurpose trees while providing income aside from its domestic use.

Only few farmers desired alternative species such as acacia (*Robinia pseudoacacia*), oak (*Quercus robur*), common jujube (*Ziziphus jujuba* Mill) or hawthorn (*Crateagus* L.) for aesthetic reasons. Farmers stated that these trees were most apparent in urban settlements, where they are grown for such purposes. Although common jujube and hawthorn were believed to have medicinal effects, not one farmer desired including these species in their plantings.

Table 8. Occurrence (in number and frequency) and ranking of farmers' future preferences in tree choice (N=35), 2005.

Tree species	Number	Frequency (%)	Ranking
Fruit trees	35	100	1
Populus spp.	33	94	2
Salix spp.	22	62	3
Ulmus spp.	16	45	4
Eleagnus angustifolia	16	45	4
Morus spp.	16	45	4
Populus euphratica	4	11	5
Other*	4	11	5

Other* - common jujube, acacia, oak, hawthorn

4 DISCUSSION

Characteristics of the AF systems: The type of tree intercropping systems monitored in Khorezm has a long tradition and dates back to the times, when people started to plant trees on pastoral lands, on their farmland or around their homesteads to cushion the extreme temperatures that can occur in the cold winters and hot summers. Although this tradition could not be pursued during the soviet epoch, following the land reforms initiated after independence, private tree planting was revitalized (FAO 2006). However, since the natural environmental conditions in the Khorezm region do not favour tree growth, only a relative small variety of species can be found. Broad-leafed species are hardly present in Uzbekistan where the bulk of the species consists of typical semi-deserts species such as Saxaul (*Haloxylon* spp.) and other bushes and in the flood plains the tugai forests (Gintzburger et al 2003).

On the other hand, Khorezm's climate conditions favour the open-field production of annual, warm-season crops, reason why during the Soviet era, Uzbekistan was a supplier of early harvested vegetables to other Soviet republics. Yet, these crops were cultivated on large, specialized state and collective farms. After independence, the vegetable production sector collapsed (Olimjanov and Mamarasulov 2006) which may explain that the diversity of vegetable and forage crops did hardly differ among the farms and represented the commonly cultivated vegetables and forage crops throughout the region (Djanibekov 2008; Ali et al. 2003).

Noteworthy is the case of including rice (*Oryza sativa*) in the tree-crop system and more particularly in combination with winter wheat (*Triticum aestivum*), vegetable or forage crops. Although various farmers underlined this practice, theoretical knowledge and experience claim that this type of cultivation is bound to fail when the rice, as was the case, is cultivated as wetland or paddy rice: meaning flooded with water throughout the growing season. Such a practice reduces the oxygen availability to the roots of all crops and trees other than rice, that in contrast to paddy rice cultivars experience a strongly reduced growth and even an increased perishing under anaerobic conditions (Bouman and Tuong 2001; Valkov 1986). Obviously in case dryland or aerobic rice is grown, meaning under non-flooded conditions in a non-puddled and unsaturated (aerobic) soil, the changes of getting a combined growth will increase. Moreover, economizing water use for paddy rice is highly desirable in Khorezm, given the huge amounts of water (up to 2500-3500 mm) used for conventional paddy rice cropping (Djanibekov 2008). But both necessities have apparently not yet been recognized by Khorezmian farmers who are used to (over)supply water to transplanted and direct seeded rice where accurate water management is not critical (Pandey and Velasco 1999: 10) compared to e.g. bed planted rice with aerobic lines. Cultivating seemingly irrational crop-tree combinations also took place in older gardens and orchards since on these pieces of land, fruit yields turned out to be irregular or decreasing. Also the expenditures for production often exceeded the profit. Hence farmers responded with intercropping crops with the trees and thus had put their stakes on the crop production (box 1).

Box 1: Case 1 was an orchard (1 ha) located in the Urgench district. It included fruit trees combined with vegetables. The *U. pumila* strips bordered the field edges, but were thinned out. The fruit species were apple, apricot and quince planted at a spacing of 6m x 8m. The total number of trees amounted to 169, planted at a density of 208 trees ha^{-1}. The age of the fruit trees was 5 years; some of them bear fruit during the visits. The intercropped plants consisted of carrot, cabbage and tomatoes cultivars. The young trees at this site just started to bear fruits (5-6 years after establishment of the garden). The conditions for growing vegetables were most favourable. At this plot neither fruit trees nor the woody species were prioritized but instead the annual crops. The tree density was low which could potentially decrease the competition between the plants. The combination seemed to be suitable when considering the age of the trees and the optimal use of the free space.

A negligence of basic cultivation rules and the continuous employ of such practices on rare pieces of land may be an additional confirmation that self-sufficiency and subsistence farming and the additional generation of income from intercropped plants rather than trees are foremost to farmers as postulated previously (Wall and Lamers 2004).

Usually alley-crop plantings require a regular pruning to control shading and belowground competition. It was also suggested that pruned materials could be used as green manure or mulch on the associated crops to improve the soil organic matter content or to provide nutrients to the crop (Kang et al. 1990). Yet, none of these practices were recorded at the studied sites. Although the competition for light in local conditions is not as disadvantageous as compared to the competition for soil minerals, for AF systems the requirements in light for fruit trees change depending on the age.

Even though the tree arrangements were typical for tree windbreak architecture, recent in-depth analyses showed the inefficiency of their functioning (Tupitsa et al. 2006). It was concluded that well-designed multi-species windbreaks in the Khorezm region were absent but instead single-tree rows of mulberry comprised about 50% of the tree strips present. Furthermore only 70% of the tree windbreaks were oriented in the North-South and North/West-South/East directions, from which highest wind speeds (>3 m s^{-1}) are generally observed. The majority of the investigated tree strips did not satisfy the minimal height of 5 m. Nevertheless, other criteria including stand porosity, length and width had acceptable values (Tupitsa et al 2006).

Function: Forage crops were part of virtually all AF systems identified in the Khorezm region (Table 1), which indicated a priority interest of farmers in livestock rearing. Livestock feeding in the Khorezm region is primarily based on crop-by products and grazing of low quality crop residues on fallow land. This explains the relatively low milk production of 2045 l milk per year in 2001 (Oblstat 2002). Despite the importance of livestock, its production is hampered by insufficient health care, hygiene and reproductive management next to the lack of knowledge and long-term experience of the livestock keepers. Recent household studies conducted in the Khorezm *viloyat* underlined the increasing importance the rural population attributed to livestock and the role it plays in household security and regional economics (Mueller 2006; Djanibekov 2006). Official data from Khorezm showed a relatively stable number of cattle, dairy cows and small ruminants (mainly sheep) with 0.45 millions cattle, 0.19 million dairy cows, and 0.21 million small ruminants in 2001. Although the number of pigs had doubled from 3,435 in 1998 to 6,252 in 2001, it remained an insignificant number compared to the other livestock categories. This is without doubt due to the prevailing religious congregation of the rural population in Khorezm since as muslims they refrain from consuming pigs and hence the production of such animals is limited to a smaller group of ethnic Koreans.

In contrast, poultry numbers were as high as 1.2 million, of which 82 % were raised in rural households, indicating that on average each household kept about 16 poultry. Since poultry are part of the daily meals in Uzbek households, poultry numbers may vary rapidly. A recent large scale survey with *deqhon* farms, of which about 207,000 were registered in Khorezm in 2006, showed that they kept on average two heads of cattle (Djanibekov 2006). Given that the average size of *deqhon* land was only 0.15 ha (Oblstat 2005), this is an indication of a general prevailing feed deficiency. On the other hand, a recent study underscored the role various fodder trees could play in the feeding strategy (Khamzina 2006). It was suggested that trees and shrubs may represent an alternative fodder source for animal production, in particular outside the vegetation season when the diet usually consists of senescent grasses, straw from winter wheat, and hay from rice or alfalfa. Finally, in case of necessity the forage crops could also be sold.

Age: Young trees took the lions' share of the trees at the surveyed sites, which is a clear indication that the number of land-users interested in tree planting had increased in the very recent past. Following the completion of the land reforms in 1998, which allotted the rural population land ownership, the relatively young age of the trees was a clear indicator for the only recently developed interest for planting trees. The latter seems to be conducive by several socio-economic reasons as well such as by obtaining a five year land tax exemption and under some conditions freed from various taxes such as income and property taxes as well as the value added tax for three years.

The diversity on the one hand and the intensity of land use on the other evidenced that the cropping schemes were influenced by the tree age. Farmers deliberately selected a land use which was guided chiefly by economic and financial reasons rather than optimizing the technical aspects of an AF system. Also the availability of land resources determined the choice of the crop combination. The age of tree plantations served as a limiting factor compelling farmers to introduce, or on the contrary even exclude, certain components in the AF system which was obvious with the systems dominated by fruit trees since these were associated in particular with forage and vegetable crops which can tolerate moderate shading (box 2).

Box2: The area of this orchard of 2 ha, was triangular shaped. The dominating apricot and peach species were planted at a spacing of 4m x 8m, the density was 312 trees ha^{-1}. The age of the trees was 7 years. Vegetables (in particular potatoes) and forage crops (sorghum) were the main understorey crops. The bordering trees, which surrounded the entire field, included poplar and Russian olive species. The crop combination at this site was defined as "Fruit trees +Wood trees + Forage crops" (No. 8,Table 1). Given the dominance of apricot species, in particular the interaction between the apricot, vegetables and sorghum root systems was reflected with the farmer.

Apricot has usually rather shallow root irrespective the soil texture and even at an advanced age. Ribakov (1959) disclosed that although the roots of 17 years old apricot trees had reached 0,6-0,9 m depth, the root mass basically was located at 0,5 to 0,6 m, whereas the horizontal roots had spread 5,5 -10,5 m. Although roots when horizontally projected, may reach an area 1.5-3 times larger than the projected crown, the bulk root mass lays nevertheless directly underneath the crown. Due to the low fertility of the soils in the Khorezm region, very likely the roots can extend further in the search for nutrients.

The root system of potato is in contrast weakly developed compared to other crops. Yet, the growth and development of its roots is rapid particularly after planting, but basically are limited to a depth of 0,3-0,6 m. Moreover, the rooting depth and distribution over the soil layers depended on the irrigation rates. In a serozom soil the bulk root mass (75-80%) was concentrated in top 0-30 cm, irrespective of the irrigation norm but in the 30-50 cm layer not more than 10-15 % and only individual roots (2,4 % total mass) reached deeper layers by the end of vegetation. The roots of red beet may reach 1,5 m depth in sandy and 1,8 m in irrigated soils, but they do not extend and occupy much of vertical space (60-90 cm). Tomatoes have their roots at the depth of 30-60 cm, but may extend 1,2 m in horizontal directions. The root system of the eggplant is branchy and is located mainly at 30-40 cм depth. Cucumber roots are located mainly at the depth of 30 cm. Thus, though plants may differ by their rooting depth, the bulk of the roots basically develop in the same soil layers. Therefore, it is likely that plants with various root systems will use nutrients and water at the same depth. This seems in particular true in an environment where the rooting depth is limited by a shallow ground water level, which also encourages horizontal rooting.

Poplar trees bordered two sides of the garden whereas a third strip consisted out of a mix of *Populus* and *Eleagnus* species. The tree shelterbelt could create a favorable microclimate in summer and winter as compared to an open field. The water loss considerably decreased both from the soil surface and by plants. The included Russian olive could favor the soil texture improvement at adjacent sites and N accumulation by this N-fixing species. It is possible that the competition effect at this field could be decreased owing to the leaf litter as an additional source of nutrients and organic matter.

Taking into account the surface rooting of both vegetables and fruit trees, as well the high planting density, the crop-tree competition seems to be very likely at this site.

Density: The wide variety in tree stand density may on the one hand be explained by the different demands of the tree species but on the other hand also by a certain level of ignorance of the land users. Dense plantings may be acceptable for peach, cherry and plum trees, which are often hallow rooters (Rybakov 1959). However, considering the dominance of apple, apricot and pear, this high density may affect both trees and crops. For example, in an experiment with Eucalyptus trees, a reduction in spacing increased the tree rooting depth, whilst the root density turned out to be independent of the vertical roots (Nair 1985). Besides, at that age the tree root system was already well developed, particularly horizontally, which affected the growth of the neighboring crops (Nair 1985). It is known that a wider stand density facilitated a sufficient aeration inside the tree crowns.

The recommendations on the planting distance issued by the Fruit Growing Institute (MAWR 2004) in Khorezm, were determined by the nutritional demand of the trees and had been set at 6m x 8m and 6m x 4m for drupaceous and seminal species resulting in a planting density of 208 and 416 trees ha^{-1} respectively. Yet, such recommendations were determined for pure tree rather than the mixed stands applied by farmers. The optimal density for combining various fruit species is therefore subject to much debate, since the probability to correctly implement a wide assortment of species and concurrently fulfilling the requirements to the benefits of both crops and trees on one and the same site, usually is relatively small. E.g. requirements for plant and tree growth such as light, temperature, air, water and soil mineral do differ, not only between crops and trees but also between the crop and tree varieties. Moreover, the demand for specific nutrients depended on the species, assortment, age of trees as well the growth stage of plant (Krayushkina 1987). Apple trees e.g. absorb more nitrogen and potassium, than phosphorus, whilst plum trees require in general 3-5 times more than apple (Krayushkina 1987). Plum and apple are considered to be the most water loving plants compared to cherry and pear. To reduce the depressing influence of the inter-row crops on fruit trees, it is important that the former have sufficient place and access to minerals (box 3).

The high density of wood trees was geared to the intention of getting high quality construction wood. Although farmers were thus aware of the potential protection function of the shelterbelts, simultaneously they had insufficient knowledge about the selection and placement of tree species to realize this goal or were even not interested in the ecological benefits of shelterbelts.

Box3: Case 3 was an apple garden located along the main road in Khonka district with a farm size of 1 ha. The woody tree species (mainly *P. nigra*) were planted only along two field edges: the roadside and as a border with the neighboring garden. The age of the fruit trees was 6 years. In addition, the site included newly planted trees. Trees were intercropped with maize. The tree stand density was 285 trees ha^{-1}. Fruit trees were planted at a spacing of 5m x 7m.

The AF management at this site can be viewed in terms of the potential root competition between trees and the associated maize. The rooting depth of apple tree at the age of 6 is to be expected 1.5-1.8 m. The roots of maize are initially present in the topsoil layer, but during the growth can reach a depth of 2.4 m and may spread up to 0.9-1 m aside. Therefore, the basic mass of both apple-tree and maize roots is located at the same depth that can bring about a mutual competition between crop and tree. But given the abundant space between the young trees and assuming that these have a shallow root system the belowground competition is supposed to be relatively weak.

The boundary plantings comprised mature poplars can be competitive with plants in the adjacent fields, since the poplar root system is relatively deep and extended with numerous surface roots. The competition for water between the roadside shelterbelts and fruit trees at this site was unlikely since a canal separated both. On the contrary, the bordering strip between this and the neighboring field may cause a competition for sites in the vicinity. However, this negative aspect can be compensated by the protection function of this poplar strip and the microclimate it may create. *P. nigra* is more resistant to water and nutrient deficiency as well as to soil salinity compared to maize and fruit trees.

Between the neighboring plants a competition for nutrients may occur. This is not surprising since various plants need the same resources, and their roots tend to grow in the areas, where those resources are prevailing usually in the topsoil layers (Lyr and Hoffman 1967). The soils in Khorezm are mostly characterized by low inherent fertility (Fayzullayev 1980). Nutrient deficiency and thus the plant competition could be aggravated when farmers have insufficient funds for applying fertilizers. Nevertheless, this farmer was satisfied by the status of his farm, however pointing to the instable fruitage of the apple trees.

The competition among various crops was highly likely at this site, since shallow rooting depth, insufficient moistening and deficient nutrient supply did not favor the growth of trees and plants. Yet, the farmer was not keenly aware of the recommended plant density, irrigation and fertilization frequencies and norms, which were necessary for the trees. Whilst managing his farm he was guided mainly by the maize requirements only and availability of resources.

Tree use: The findings showed that the production of fuel wood was not a primary consideration for farmers. The need for wood from trees is conditioned by the season and is high in autumn and winter periods, when in the rural areas the insufficient gas supply becomes a pressing problem (FAO 2006). During these conditions the trees in the public shelterbelts are logged although such gaps render tree shelterbelts not only inefficient but in fact may engrave the danger of erosion (Tolchelnikov 1990; Lopirev and Ryabov 1989). Furthermore, the use of tree species depended strongly on the land tenure situation. The cutting of woody trees was prohibited for land users compared to the owners of such plantings. This may explain the low interest of farmers for the choice and cultivation of wood species and trees. Also the own woody trees were in the first place perceived for construction purposes, reason why poplar species were preferably cultivated.

The soft and light poplar wood was used for roofing. The surveyed land-users considered management of poplar as easier, and it allows a certain coppicing and re-grow after cutting. Growing trees for fuelwood can become an option on the farms, where the irregularities in gas supply are the most frequent.

Despite the fact that the majority of farmers indicated the use of trees as windbreaks, recent findings evidenced that the numerous plantings along canals and fields did not perform this anticipated function, i.e. protection the agricultural lands from wind erosion. The mixing of species in tree windbreaks occurred not with the purpose to improve the growth of the major and neighbouring trees, but rather to receive various products. This is exemplified in the production of the mulberry tree, which leaves serve as fodder for silkworm, but that due to recurrent coppicing is concurrently lowered in height. This obviously reduces the efficiency of such as line of trees as a shelterbelt. Moreover, in most of the farms the established tree shelterbelts did not surround the entire field, but only partially, thus leaving open gaps, which could even worsen the situation (Tolchelnikov 1990; Tupitsa 2006).

Crop-tree interactions: Decomposition of leaf litter plays a prime role in nutrient recycling of ecosystems (e.g. Kurzatkowski et al. 2004; Lavelle and Spain, 2001) as was shown also for Khorezm region (Lamers et al. forthcoming). Yet, the decay rates of the different species were influenced by chemical components (e.g. CF/N ratio), morphological traits (leaf area or specific leaf area) or the type of fauna. The mention by farmers that a continuous drop of leaf litter changed the surface or relief of the garden and consequently rendered irrigation activities more difficult could not be confirmed. Yet, recent research in the Khorezm region showed that annual fall of litter in a forest plantation over a period of 3-4 years did not change soil properties significantly (Khamzina et al. 2005a). In contrast, farmers were unaware of the N-fixing properties of *E. agnustifolia*, although the amount fixed could be substantially (Khamzina et al. 2005b). In addition, the surveyed farmers were not aware of using in particular the Russian olive for N-fixation and biodrainage purposes.

The attributed halophytic characteristics of *E. angustifolia* could not be confirmed by research findings. In fact, the opposite seems to be true not only with respect to *E. angustifolia* but with others species as well (Khamzina et al. 2005a). Whereas *E. angustifolia* was the leading tree species with regards to its water use characteristics, followed by *U. pumila*, *P. euphratica* and *P. nigra*, and hence the ground water table was lowered by these species, there was concurrently an accumulation of salts underneath such plantations (Khamzina 2005a). But even if such a build-up may occur, a frequent leaching may bypass this disadvantage. Also the claim that in the presence of trees water was kept in the soil, appears to be disputable, because trees are the major water consumers.

Moreover the growth of tree roots depended on the ground water level (GWL). According to the Uzbek Soil Institute, most of the irrigated lands in Khorezm (77.2 %) have a GWL of 0-1.0 to 1-2.0 m whereas the salinity makes up 5-10 g L^{-1}. MAWR (2001) showed for 1988-2001 that about 10 % of the territory of Khorezm had a GWL higher than 2.0 m and a salinity of 3-10 g L^{-1}. As it is known that the shallow saline GW leads to a more surfaced and horizontal rooting it hence bears the danger of an unavoidable competition. At a GWL of 1.20 m in meadow soils, apple trees developed only horizontal surface roots (Vashenko 1980). Furthermore, the plants perished due to an accumulation of the readily soluble salts in the root-inhabited layer, as well as owing to the consequent water logging with the development of oxygen-free environment and accumulation of toxic manganese and ferrous oxides. Moreover, in arid and moderately dry conditions the moisture coefficient of 1.0 can be critical mainly due to the GW high salinity (0.5-1.0 g L^{-1}). Khorezm is among the areas of insufficient water where the evaporation exceeds the precipitation and therefore the water supply is of vital importance (Glavgidromet 2002). Finally, young trees and maize are particularly in the first part of the growth cycle very sensitive to nutrient deficiency and salt stress and therefore are less compatible in conditions of untimely water supply, which was frequently observed according to farmers.

When exposed to adverse ecological conditions, trees tend to complete earlier their growth cycle (Ivanov 1986). On the other hand, this general rule does not seem to hold for fruit species with a higher salt tolerance, or under different crop management practices (Ivanov 1986). Although the conclusions on salt tolerance of fruit trees do contradict each other, most observations point to a low salt resistance. It is generally accepted that among fruits species, quince is most salt tolerant and therefore preferred for more saline areas (Ivanov 1986).

Also the observation that a combination of crops and trees enhances apicultural activities seems to have been recognized by previous research. A favourable microclimate may extend the blooming period and increased activity of bees, which results in better fruit production and early maturity (Norton 1988).

Despite various remarks about the shading effect of trees on the under storey crops, there was no mention of pruning or trimming, although a timely pruning of trees can modify the growth rates (Steudle 2000). Also the requirements in water and nutrients can be decreased due to the crown pruning, which in its turn may result in a reduction of root biomass and increase in soil fertility beneath the trees owing to fine roots' decomposition.

Motivation of tree planting: Although the motives for tree planting were understandable, the additional explanations given could not always withstand a scientific assessment (Table 9). E.g., prior to the regular fruit bearing, the land users tried to use the available area underneath the trees for obtaining an additional income. This makes a lot of sense from a technical point of view in younger plantations, the same was observed however in older orchards, where the root systems and crown of fruit trees occupied a large space which definitely leads to a competition between the plant layers (box 4).

Therefore, this practice frequently brings about a decrease in both tree and crop yields and contradicts with AF principles, which envisage the handling of the possible competition between the different layers. Although a simultaneous management of crops and trees indeed is time saving, the fact that the timing was set by the annual crop is from the perspective of AF ideal for obtaining e.g. the highest yield and income in particular with a mismatch of certain crops and trees or when a more accurate selection of trees and crops is needed.

Box 4: At this site fruit species were intercropped with winter wheat and sorghum. The area of the field was 1 ha. The spacing for fruit trees was 6m x 7m, the total tree number 196 trees, which was lower than the recommended density. The age of trees was 6 years. Dominant were apple and peach species. According to their age, the trees in this garden entered the second growth period, meaning the start of fructification. The conditions to grow the associated crops at this period were satisfactory.

The woody plantings included mainly poplar species, and some elm, willow and Russian olive trees, in a two-row structure. As in most of the cases, such plantings were located close to the paved road and at the border with another field. The distance between the trees was between 0,5-1 m. Such extremely high density for woody species was observed in many cases. Though appropriate by the height, this shelterbelt was not sufficiently extended and obviously did not perform its ecological protective function.

In general fruit tree root systems may extend to a depth of 1,5 – 2 m, but the roots basically occupy the 0,6 m layer. The fibrous roots of wheat mainly occupy the topsoil but individual roots can reach 2 m depth. During the vegetation wheat absorbs 80-85 % of nutrition elements from the topsoil, 15-20 % from the lower soil layers. Thus, more than 95 % of nutrients are consumed from the 0-60 cm layer (Shatilov and Safonov, 1973).

In many respects the vigor of sorghum for adverse growth conditions is due to its strong and branchy fibrous roots, which grow predominantly at 1,8-2,5 m. The root mass alike the most of heat tolerant plants exceeds the aboveground biomass and is larger than of the other annual crops (Mokin, 1957).

In spite of the difference in morphology due to the high GWL in Khorezm, the roots of both wheat and sorghum and the perennials occupy the same soil layers and compete for nutrients and water. Even tree species known as deep rooting, such as *E. angustifolia* and *U. pumila (*Forestry Compendium, 2000*),* appear to have an overwhelming part of their total root biomass in the upper horizons (Khamzina 2005a). Although many shallow coarse roots are pruned during tillage activities every season, root system excavations showed that root dry matter within 1.0 m soil depth still averaged to 68% and 99%, respectively, for the two mentioned species. Single roots of *U. pumila* individuals had a maximum radial extension of up to 27 m, thus growing far into the adjacent cropped area. Within the garden, where the planting density was lower than recommended, the competition should be relatively weak. Yet, according to the farmer whilst selecting this planting density it was not his intention to create optimal growth conditions for fruit trees but to allot the larger areas with priority to wheat and sorghum.

During the visit cows were left grazing the garden fields and the farmers claimed that it could be an additional source of organic matter and increase soil fertility, and also to lower the competition. The land user was confident that livestock grazing was not harmful to his garden, but rather improved crop yields. He planted trees and crops primarily for home consumption, and only when necessary for sale.

Table 9. The overview of farmers' and researchers' knowledge.

Farmers knowledge	Researchers Knowledge	Source
	Positive aspects	
Trees protect the crops from wind	Direct effects can be physical deformation of plant parts. Indirect effect concern with the water balance of the plant and the moisture content, erodibility and other properties of the soil. Though the trees compete for available water along the edges between the windbreak and the crop rows, potentially reducing crop yield near the windbreak, the net effect on productivity is positive. Even on land that's well suited for high-value crops, a windbreak can increase the crop yield of the entire downwind field by as much as 20%.	Grace 1988; Coutts & Grace 1995
Trees are good for pest control	Trees increase air humidity, which favors microorganisms, provide shelter for herbivores, which damage the crops, and reduce pest and disease tolerance of competition-stressed crops.	Garcia-Barrios and Ong, 2004.
Trees suppress the weed growth	Trees can reduce weed populations and change weed floristic composition towards less aggressive, slow growing species.	Leibman and Gallandt 1997
Common use of nutrients	Tree and crop roots occupying different soil depths can result in enhanced levels of nutrient uptake and reduces losses from soils in AF systems, compared to sole crop stand with more localized and shallow rooting depths.	Buresh and Tian 1997.
Fruit trees attract bees	The moderated microclimate in shelter contributes to longer flowering periods and increased bee activity, and can result in improved fruit set and earlier maturity.	Norton, 1988
Soil improvement	Trees can add considerable amounts of organic matter to the soil and slow down its decomposition rate, improving soil fertility and physical structure. Trees' roots can stabilize loose soil surfaces, which together with tree litter cover, reduces erosion. They recover leached nutrients from deep soil or bedrock layers inaccessible to crops. Trees can make more phosphorus available via mycorrizha and fix important amounts of nitrogen, which can be transferred to the crops via shoot and root prunings.	Young 1997; Rao et. al. 1998; Giller 2001;
	Negative aspects	
Tree root development	Tree roots can potentially reach below the crop root zone, and thus use water accumulated deeper in the ground when the crop is growing; after the crop is harvested, they can use whatever residual available water is found in the crop root zone; and they can use any additional rain which falls outside the crop growing season. Cutting the lateral tree roots extending into the crop field is a possible practice to reduce the below-ground competition. The effectiveness depends on the rooting patterns, the depth of root pruning and soil moisture levels. Under limited moisture conditions, root pruning significantly increases crop yield within the zone of competition.	Ong et. al.1996 Rasmussen and Shapiro 1990; Hou et al.2003; Jose et al. 2004)
Shading	Tree shade can reduce leaf temperature and evaporative demand experienced by crops, increasing the latter's water productivity (i.e., g of dry mass per g of water transpired). The net shade effect is more positive (or less negative) when the annual crop is a C3 plant which is normally light saturated in the open, so partial shade may have little effect on assimilation or even be beneficial.	Ong et. al. 1996;

5 SUMMARY AND CONCLUSIONS

The last 15 years have been challenging to the Uzbek farmers. The realization of land use rights, albeit on smaller areas, and the urge for the farming population to optimally exploit these areas has led to a revival of AF and tree intercropping systems. This offers on the one hand unprecedented challenges for forestry research, which by all means should not be conducted in isolation anymore. Only when considering the complexity of these systems, a holistic view can be gained.

Farmers' knowledge complied with knowledge generated by researchers (e.g. about various effects of shading, soil improvement, root competition). Yet, only a reduced number of aspects of this collective and commonly shared knowledge were mentioned. It appeared that many farmers know a little, but few know more. E.g., root competition was neglected in most cases and a principal concern was the maintenance of the crop, but the tree component was mainly alien. Moreover, the trees and crops in Khorezm develop a shallow rooted system due to the high and saline ground water level. Due to the saline groundwater, the majority of crops and fruit species prefer to use the more fertile and regularly irrigated topsoil layers. Thus, the competition for water and nutrients is inevitable, yet additionally can increase depending on soil salinity level, typical for Khorezm conditions. Although most farmers expressed some basic, theoretical knowledge on tree and crop management, this was not always mirrored in the practices and much was learned by trial and error. Land users often tried to find a suitable compromise between technical aspects, practical considerations and socio-economic factors.

Although widely practiced, the tree intercropping systems in the study region have not been put on a sound scientific footing and there is still much left to be desired, since forestry research has hardly been conducted to explore the tree intercropping systems. Essential would be to accumulate knowledge further on the characteristics of species planted to an extent that the strength and weaknesses can be revealed. Unfavourable conditions for growth and the crop competition should be minimized by well thought-out cropping technology, which includes the rational selection of the crop-tree combination, irrigation and fertilization in accordance with plant requirements, as well the properly designed tree planting pattern.

It is important to take proper account of the natural conditions, as well the crop management practices and the system "climate-fruit plant-growing technology". A systematic and complex approach is a condition sine qua non of the scientifically based and rational tree intercropping system management.

While there is in Uzbekistan a growing widespread concern for environmental services, it remains debatable if an increase in tree stands can be expected given the presently low and limited knowledge in sustainable tree and forest management as well as the lack of funds and lack of continuity in funding. The future very well may lay in the support of the private sector, community groups and civil society organization in particular since forestry by all means is a long-term investment, but this needs an enabling political will and understanding. It is therefore necessary for the administration to seize this opportunity. One option could be the initiation of extension services and adult education approaches in the training and education of farmers and gardeners, which should be beneficial from the viewpoint of both communities and foresters.

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