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The Role of Green Spaces in Biological Control of Sunn Pest (*Eurygaster* spp. (Scutellaridae: Heteroptera)) Konya Province' Turkey Sample

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ABSRACT

Natural or man-made, green spaces has now taken on a new value and function, the importance of which is widely acclaimed within the parameters of sustainable development. The protection of natural balance and biodiversity are one of the most important functions of green spaces. The increasing importance of biological control against pests had also recently increased the importance of green spaces in terms of plant protection. Then, the improving of environmental conditions of local natural enemies located in the food chain is vital precaution in the biological control. Afforestation and arrangement of green space is the first and most important step to be taken in this regard. In Konya Province of Turkey, 1-1.25 million hectares of cereal are grown in every year, and therefore it called as "Cereal store of the country". Sunn pest (*Eurygaster* spp.) is the most important cereal pest in Turkey. Chemical control measures started in 1950's have been carried out increasingly. *Trissolcus* spp. (Hymenoptera: Scelionidae) is the most effective biological control agent to decrease the population level of the Sunn pest. However these parasitoids are generally present in Turkey, except a few parts where polyculture farming is widespread; they are insufficient to solve the problem. Thus, to increase their population and be more effective they should be supported. It is a known fact that there are few studies on "protection and creation of green spaces in nature regarding to natural enemy-host relations" which is thought to provide great contributions to biological control of the problem. However, in near future, in terms of frame of IPM, the importance of this subject will definitely further increase. The Turkish ministry of agriculture has started national sunn pests project in 2004 to develop and dissemination of biological control. In this study, the afforestation efforts aimed supporting IPM studies against sunn pests in Konya province are summarized. Additionally, some recommendations were developed about gren space planning and plant species which can be useful in that planning.

1. Introduction

Natural or man-made, green spaces has now taken on a new value and function, the importance of which is widely acclaimed within the parameters of sustainable development. The protection of natural balance and biodiversity are one of the most important functions of green spaces. The increasing importance of biological control against pests had also recently increased the importance of green spaces in terms of plant protection. Then, the improving of environmental conditions of local natural enemies located in the food chain is vital precaution in the biological control. Afforestation and arrangement of green space is the first and most important step to be taken in this regard. In Konya Province, 1-1.25 million hectares of cereal are grown in every year and therefore it is called as "cereal store of the country".

Sunn pest (*Eurygaster* spp.) is the most important cereal pest in Turkey. If the precautions are neglected, damage rate (%) can probably reach 100%. Chemical control measures started in 1950's, and have been carried out

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increasingly. But, in recent years, biological control has gone to the fore and taken the quite successful results (Topal, 2011). The aims of biological control are the establishment and protection of natural balance, so, the first method which is the most important one, is conservation and enhancing the natural enemies' performances as well as emphasis to provide overwintering refuges and alternative preys and hosts for parasitoid and predator species to achieve success in biological control programme.

In account of the success of the biological control, the presence of plant vegetation and their diversity are indispensable items in the control programme of sunn pest.

Trissolcus spp. (Hymenoptera:Scelionidae) are the most effective biological control agent to decrease the population level of sunn pest. However, these parasitoids are generally present in Turkey, except a few parts where polyculture farming is widespread; still insufficient to solve the problem. Thus, to increase their population and be more effective they should be supported.

It is a known fact that there are a few studies on "protection and creation of green spaces in nature regarding to natural enemy-host relation" which is thought to provide great contributions to control the problem, biologically. In near future, in terms of frame of IPM, the importance of this subject will definitely increase.

In the present study, releasing of parasitoids and afforestation efforts supporting IPM studies against sunn pest in Konya Province are summarized.

In addition, some recommendations were also developed about green space planning and plant species which can be useful in mentioned planning.

2. The efforts supporting IPM studies in Konya Province' Turkey

The Turkish Ministry of Food, Agriculture and Livestock took a decision about chemical control applying methods in sunn pest control and only allowed to do spraying with local instruments by farmers instead of aerial practices in 2003 to protect the environment on a large scale from the side effects of pesticides. This was really first important step about the supporting of biological control. And then, it has started national sunn pests Project in 2004 to develop and dissemination of biological control.

The afforestation efforts and releasing of adult parasitoids in constitution of biological control, the rates of parasitation (%) and damaged kernel rates (%) from 2007 till today were given in Table 1.

Between 2007 and 2014 (for 8 years), totally, 5.730.675 shoots were planted. Additionally, 27.280.000 *Trissolcus semistriatus* were released. While the number of insects that are released is increasing, the rates of parasitation (%) paralelly increase, too. As it can be seen in Table 1, released parasitoid number was very low which should be, because rearing of them is quite expensive and not very easy. That's why, parasitation rates are also quite low, too. However, there are a few effects of releasing parasitoids on the parasitation rates, according to the results which lower than 20% before 2007. The average of 8 years, project carried out, is 39%. That means that approximately 20% increasing occurred in parasitation rates.

Contrary, damaged kernel rates (%) were gradually decreased. Even the parasitation rates were quite low, damaged kernel rates were approximately 1 in recent years, while was up to 5 in the past. That's mean success.

This success are more relate to the total effects of other precautions and studies, carried out parallelly, in frame of Sunn Pest IPM programme of the Turkish Ministry of Food Agriculture and Livestock besides the efforts of releasing parasitoids.

It can be said that instead of releasing parasitoids, supporting them in nature seen to both practical and consistent. So, the target should be mostly establishment of natural biological control in the sunn pest control.

3. The Arrangements of The Green Spaces and Agricultural Practices for The Impact and Consistency of Sunn Pest' Parasitoids

The egg parasitoids *Trissolcus* spp. are very effective in the area of natural balance not yet disturbed, rich for both trees and natural flora which supply to the parasitoids feeding and shelter source.

To increase the effectiveness of egg parasitoids, natural flora should be enriched and abstain from intensive chemical control applies (Tekşam et al., 2013; Şimşek et al., 2015). After harvesting the wheat, parasitoids are in need of an environment with feeding and shelter. That's why; it's of great importance especially to have pollen, nectar or honeydew on plants and certain thick barked trees and shrubs around the fields in one way.

4. The following properties of the Plants and Shrubs are important for Consistency of Parasitoids in the biological control

- Should giving nectar, pollen and have lots of flowers
- For overwintering sites, thick barked trees and shrubs should be planted (*e.g.* Rosaceae family).
- From spring to fall, they can flower in long term at different times so that parasitoids can be fed regularly (*e.g.* Leguminaceae family, *Medicago* spp.).
- Especially annual plants should have the characteristics mentioned above.
- We should choose plants that host of insects like aphids, coccids etc.
- Sunn pest are seen in dry areas. So, the plants must be harmonious with those areas and can be growing fast.

- ❖ The plants can be a source of income and planted around the field and should be appropriate to plant around the field.
- ❖ It can be use in pasture areas (perennial, have plentiful flower, nectar, pollen) as food supplier.
- ❖ It should not have negative effects on growing and farming of wheat and other crops'.

5. We can Gather the Proposed Plants in Terms of Practices as Follows

The trees and shrubs which can be used in green belt, windbreak, near water source and roads given in Table 2 and Fig 1.

Elaeagnus angustifolia is a deciduous shrub growing to 7 m at a medium rate. It is hardy to zone (UK) 2 and is not frost tender. It is in flower in June, and the seeds ripen from Sep to October. The flowers are hermaphrodite and are pollinated by Bees. It can fix Nitrogen. It prefers dry or moist soil and can tolerate drought. The plant can tolerate maritime exposure (Anonymous, 2015a).

Robinia pseudoacacia, also known in its native territory as black locust, is a tree of the genus *Robinia* in the subfamily Faboideae of the pea family Fabaceae. Flowers: May or June, after the leaves. In Europe, it is often planted along streets and in parks, especially in large cities, because it tolerates pollution well. The species is unsuitable for small gardens due to its large size and rapid growth. Black locust has nitrogen-fixing bacteria on its root system, so it can grow on poor soils and is an early colonizer of disturbed areas (Anonymous, 2015b).

Morus alba is a tree which can reach over 20 m. in height. The tree generally has a deep tap root with little surface rooting which makes it suitable for use near crop land. It prefer deep soils and need good drainage; It is frost resistant. It can be grown opportunistically around house-compounds, on spare pieces of land and along field edges (Anonymous, 2015c).

Amygdalus communis is also the name of the edible and widely cultivated seed of this tree. It is a deciduous tree, growing 4–10 m in height. The flowers are white to pale pink and appearing before the leaves in early spring. It grows best in Mediterranean climates with warm, dry summers and mild, wet winters (Anonymous, 2015b).

Rosa canina, commonly known as the dog-rose. It is a deciduous shrub normally ranging in height from 1–5 m. The plant is high in certain antioxidants. The fruit is noted for its high vitamin C level and is used to make syrup, tea and marmalade. (Anonymous, 2015b)

Prunus spinosa (blackthorn, or sloe) is a species of *Prunus* native to Europe, western Asia, and locally in northwest Africa. *Prunus spinosa* is a large deciduous shrub or small tree growing to 5 metres tall. The shrub is traditionally used in Northern Europe and Britain in making a hedge against cattle or a "cattle-proof" hedge. (Anonymous, 2015b)

The trees which can be used in orchards in the wheat field areas given in Table 3 and Fig 2.

Pyrus communis, known as the European pear or common pear, is a species of pear native to central and eastern Europe and southwest Asia. Relatively few cultivars of European or Asian pears are widely grown worldwide. (Anonymous, 2015b)

Malus ssp. is a deciduous tree, generally standing 1.8 to 4.6 m tall in cultivation. Different cultivars are available for temperate and subtropical climates. (Anonymous, 2015b)

Prunus cerasus (sour cherry, tart cherry, dwarf cherry, or wild cherry) is a species of *Prunus* in the subgenus *Cerasus* (cherries), native to much of Europe and southwest Asia. *Prunus cerasus* is thought to have originated as a natural hybrid between *Prunus avium* and *Prunus fruticosa* in the Iranian Plateau or Eastern Europe where the two species come into contact. (Anonymous, 2015b)

Some plant species which have nectar and pollen and we can use them for polyculture farming in the field areas given in Table 4 and Fig 3.

Medicago sativa is a perennial flowering plant in the pea family Fabaceae cultivated as an important forage crop in many countries around the world. It is moderately sensitive to salt levels in both the soil and irrigation water, although It continues to be grown in the arid southwestern United States, where salinity is an emerging issue. It is considered an insectary, a place where insects are reared, and has been proposed as helpful to other crops, such as cotton, if the two are interplanted, because the alfalfa harbours predatory and parasitic insects that would protect the other crops. (Anonymous, 2015b)

Citrullus vulgaris (*C. lanatu*s) is a plant species in the family Cucurbitaceae, a vine-like (scrambler and trailer) flowering plant originally from West Africa. The subdivision of this species into two cultivars, watermelons (*Citrullus lanatus* (Thunb.) var. *lanatus*) and citron melons (*Citrullus lanatus* var. *citroides* (L. H. Bailey) Mansf.). Stems are up to 3 m long and new growth has yellow or brown hairs. Plants have both male and female flowers on 40-mm-long hairy stalks. (Anonymous, 2015b; Acar et al., 2014)

Helianthus annus is usually tall annuals, that grow to a height of 50–400 centimeters. They bear one or several to many wide, terminal capitula (flower heads), with bright yellow ray florets at the outside and yellow or maroon (also known as a brown/red) disc florets inside. (Anonymous, 2015b)

Fagopyrum esculentum is a plant cultivated for its grain-like seeds, and also used as a cover crop. *Fagopyrum esculentum* has triangular seeds and produces a flower that is usually white, although can also be pink or yellow. (Anonymous, 2015b; Acar et al., 2011)

Fig 1
Some plant samples used in shelterbelt and windbreak (**a-***Acacia* spp. **b-** *Eleagnus orientalis* L.)

Fig 2
The orchards at around the wheat field

Fig 3
a) *Fagopyrum esculentum* b) *Citrullus lanatus*

Fig 4
a) *Onobrychis sativus* b) *Medicago sativa* c) *Trifolium repens*

Fig 5
Salvia spp.

Table 1

Afforestation efforts and releasing of adult parasitoids in constitution of biological control, the egg parasitation rates (%) and damaged kernel rates(%) in Konya Province*

	Years								
	2007	2008	2009	2010	2011	2012	2013	2014	Total
Planted shoots numbers	1,420,085	2,120,800	796,834	833,629	376,342	72,785	72,000	38,200	5,730,675
Released parasitoid numbers	4,450,000	6,000,000	4,500,000	3,750,000	2,200,000	2,200,000	1,200,000	1,000,000	27,280,000
Egg Parasitation rates (%)	26.8	32.9	38.7	45.8	40.4	48	43	37	39
Damaged kernel rates (%)	1.5	1.3	1.17	1	0.8	0.85	0.9	0.7	1.02

*Reports of Konya Directorate of Provincial Food, Agriculture and Livestock

Table 2

The trees and shrubs which can be used in green belt, windbreak, near water source and roads

	Plant Name	Scientific Name
Trees	Russian silverberry	*Eleagnus angustifolia* L. (*Eleagnus oriantalis* L.)
	Black locust	*Robinia pseudoacacia* L.
	Ash tree	*Fraxinus excelsior* L.
	Wild pear	*Pyrus eleagnifolia* Poll.
	Mulberry	*Morus* spp.
	Almond	*Amygdalus communis* L. *Amygdalus orientalis* L. *Amygdalus nana* L.
	Mahalep	*Prunus mahalep* L.
	Hawthorn	*Crataegus azarrolus* L. *Crataegus oxyacantha*
	Buckthorn berry	*Hippophae rhamnoides*
	Plum	*Prunus domestica* L. *Prunus cerasifera* Errh.
	Acacia-Myall	*Acacia* spp.
	Syrian juniper	*Arceuthos drupacea* L.
	Willow	*Salix* spp.
	Honey locust	*Gleditsia* spp.
Shrubs	Rosehip	*Rosa canina* L., *Rosa pomifera*
	Sloe	*Prunus spinosa* L.
	Laburnum (Golden chain)	*Laburnum* spp.
	Colutea	*Colutea* spp.
	Woadwaxen	*Genista* spp.
	Caper plant	*Capparis* spp.

***Brassica* spp**. is a genus of plants in the mustard family (Brassicaceae). Members of brassica commonly used for food include cabbage, cauliflower, broccoli, Brussels sprouts, and some seeds as in the production of canola oil. The genus is known for its important agricultural and horticultural crops and includes a number of weeds, both of wild taxa and escapees from cultivation. (Anonymous, 2015b)

The plants have pollen and nectar and can be used in pasture improvement and artificial pasture given in Table 5 and Fig 4.

Onobrychis sativa, also known as *O. viciifolia* has been an important forage legume in temperate regions. *Onobrychis sativa* is an open pollinating plant, mainly pollinated by nectar feeding insects. Therefore *Onobrychis sativa* is a promising crop to enhance biodiversity within agro-ecosystems. (Anonymous, 2015b)

Trifolium repens is a herbaceous perennial plant in the bean family Fabaceae native to Europe and central Asia. It is low growing, with heads of whitish flowers, often with a tinge of pink or cream that may come on with the aging of the plant. It is commonly grown in mixtures with forage grasses in pastures. (Anonymous, 2015b)

Some weed species have plentiful pollen and nectar emerging in field edges and empty areas given in Table 6 and Fig 5.

Table 3

The trees which can be used in orchards in the wheat field areas

Fruit trees	Scientific name
Pear	*Pyrus communis* L.
Plum	*Prunus domestica* L. *P. ceracifera* Errh.
Quince	*Cydonia vulgaris* Pres.
Apple	*Malus communis* L.
Almond	*Amygdalus communis* L.
Walnut	*Juglans regia* L.
Mulberry	*Morus* spp.
Cherry	*Prunus avium* L.
Peach	*Prunus persica* L.
Sour cherry	*Prunus carasus* L.

Origanum spp. is a genus of herbaceous perennials in the family Lamiaceae, native to Europe, North Africa, and much of temperate Asia, where they are found in open or mountainous habitats. The plants have strongly aromatic leaves and abundant tubular flowers with long-lasting coloured bracts. (Anonymous, 2015b)

Salvia spp. is the largest genus of plants in the family, Lamiaceae, with nearly 1000 species of shrubs, herbaceous perennials, and annuals. The genus is distributed throughout the Old World and the Americas. (Anonymous, 2015b)

Table 4

Some plant species which have nectar and pollen and we can use them for polyculture farming in the field areas.

Plant Name	Scientific Name
Alfalfa	*Medicago sativa*
Trefoils	*Trifolium* spp.
Strawberry	*Fragaria vicca*
Watermelon	*Citrullus vulgaris*
Melon	*Cucumis melo*
Zucchini	*Cucurbita* spp.
Sunflower	*Helianthus annuus*
Buckwheat	*Fagopyrum esculentum*
Colza	*Brassica* spp.
Carrot	*Daucus carota*

Table 5

The plants have pollen and nectar and can be used in pasture improvement and artificial pasture

Plant Name	Scientific Name
Alfalfa	*Medicago sativa, Medicago falcata*
Sainfoin	*Onobrychis sativus*
Trefoils	*Trifolium hybridum, T. repens*
Bird's foot trefoil	*Lotus corniculatus*
Narrow-leaf bird's foot trefoil	*Lotus tenuis*

Table 6

Some weed species have plentiful pollen and nectar emerging in field edges and empty areas

Plant Name	Scientific Name
Marjoram	*Origanum* spp., *Thymus* spp.
Knapweed	*Centaurea triumfettii*
Parsnip	*Pastinaca sativa*
Golden chamomile	*Anthemis tinctoria*
Clary	*Salvia* spp.
Ajuga	*Teucrium polium*
Dandelion	*Taraxacum officinale*
Wall-rocket	*Diplotaxis* spp.
Horse mint	*Mentha silvestris*

Diplotaxis tenuifolia is perennial plant and flowering during spring and autumn. Plant height is 30-70 cm and this plant has got deep taproot. It is used in Europe and in many other parts of the world as human food. Moreover, it can be used for animal feed, vegetable, oil plant, pasture plant, herbal medicine, landscaping and beekeeping. (Acar et al., 2015)

Between the families given above, Leguminaceae, Rosaceae, Umbelliferae, Compositae should take a part too much in polyculture because of plentiful flowering and especially given nectar and pollen characteristics (Şimşek et al., 2015; Akıncı and Sosyal, 1992; Gözüaçık and Yiğit, 2011).

5. Some of the Arrangements in Wheat Grown and Close Agricultural Areas are as Follows:

1. Giving importance to the polyculture:

Environment has vital importance for the Sunn parasitoids. The cultivation of different plants in a year, in an agricultural area, means that is a constant source as a shelter and as food. Consequently, it increases the parasitoid population.

Environmental humidity in polyculture cultivation provides a great advantage to the parasitoids. For them, after the sunn pest eggs, the plants with nectar and pollen are quite important in polyculture cultivation. As a result, as 2nd crop, while choosing the plants we should consider nectar and pollen. In addition, the second important feature to consider is choosing the plants growing and flowering at different times (Akıncı, 2008; Özkan and Bobaroğlu, 2015; Topal, 2011).

2. Protection of pastures and improvement of disturbed pastures to take in to consideration of sunn pest control strategies:

Sunn pest is originally a pasture's pest. That's why, pastures should protect in terms of both sunn pest egg parasitoids and alternative hosts (Pentatomids) of them and to supply shelter and feeding area. Especially, disturbed pastures close to the field area have to improve for the control. These areas are also important for biodiversity (Şimşek et al., 2015; Akıncı, 2008; Büyükburç, 1999; Özkan and Bobaroğlu, 2015; Öztemiz, 2008).

3. The same features are valid also while choosing orchard trees. Konya Commodity Exchange, to support sunn pest control, scattered 1,035,000 almond, 170,000 cherry, 50,000 walnut and 32,000 apricot shoots to the farmers. Konya Provincial Special Administration also dispersed 102,500 apricot shoots in 2006-2007, for the same purpose (Akıncı, 2008).

4. At around the cultivation area, constitution of green belts, afforestation of water sources and roads edges, using of trees in windbreak are indispensable. Especially in land consolidation studies, afforestation of field edges and constitution of green belts should definitely be included to the project. So, these arrangements will bring success and constituency in sunn pest control. Besides, it saves us from the difficulties of rearing parasitoids in the lab settings.

For the success of biological control, constitution the green belt and protection of the ecosystem on it have vital importance (Topal, 2011; Akıncı, 2008; Özkan and Bobaroğlu, 2015; Şimşek and Yaşarakıncı, 1986).

The numbers of trees planted to support biological control in Konya Province by the Ministry of Agriculture were given in Table 1. In addition, some private companies supported these efforts. *E.g*. Konya Commodity Exchange planted more than 3 million trees and their target is keeping this number as the same number of Turkish population.

Turkish Ministries of Forest and Agriculture have signed a protocol about afforestation works in frame of land consolidation, the areas of pasture improvement for preventing erosion (Akıncı, 2008; Mücevher et al., 2014).

5. As sown form, perennial forage crops on cereal grown areas, band system can be recommended in terms of supporting the consistence of parasitoids from spring to fall (Öztemiz, 2008; Şimşek et al., 2015).

6. The weeds which sprout in and around the wheat grown areas and suitable for supporting the egg parasitoids should be protected and should never sprayed pesticides so that they can live (Öztemiz, 2008; Şimşek and Yaşarakıncı, 1986; Şimşek et al., 2015).

The precautions mentioned above are very important for consistency of biological control and it's also reconciled with nature instead of chemical control. They have also different benefits. Such as supporting rural landscape, establishment of recreational area and prevention of erosion.

As a result: by doing the establishment of natural suitable environment for the natural enemies and natural biological control, we can keep the sunn pest under pressure and in our control (Tekşam et al., 2013; Kütük and Yiğit, 2011)

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