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RESEARCH ARTICLE

Traditional Mulching using Japanese Knotweed (Fallopia japonica) increases Ground-Dwelling Carnivorous Beetles

INAGAKI Hidehiro[1],TOYODA Yuta[1]

[1]*Shizuoka University, Shizuoka 422-8529, Japan.*

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Corresponding Author: INAGAKI Hidehiro, Shizuoka University, Shizuoka 422-8529, Japan.

Abstract

Traditional Ecological Knowledge (TEK), based on empirical data, is a valuable source of data that enables novel scientific discoveries, and its reevaluation offers novel insights for addressing sustainability challenges. In this study, we reevaluated the effects of Japanese knotweed (Fallopia japonica) mulching, a traditional practice in the mountainous areas of Japan. Our previous research confirmed that knotweed mulching is effective in increasing sugar content in certain types of crops, preventing continuous crop damage, and inducing disease resistance. In recent years, there has been a growing interest in functional biodiversity, which enhances the function of ecosystem services through biodiversity conservation, specifically on ground-dwelling organisms that prey on natural enemies. In this study, we compared the effects of knotweed mulching with rice straw mulching (a common mulch) and no mulching on ground-dwelling organisms. Although no differences were observed for spiders, there was a tendency for the Japanese knotweed mulch to increase the number of ground-dwelling carnivorous beetles.

Keywords: Traditional Ecological Knowledge, Globally Important Agricultural Heritage Systems, Japanese Knotweed (*Fallopia Japonica*), Mulching, Functional Biodiversity, Ground-Dwelling Carnivorous Beetle.

1. Introduction

Traditional activities in rural areas have emerged from long-term interactions and co-evolution between the natural environment and human society, resulting in sustainable systems that use ecosystem services while conserving the natural environment (Altieri et al., 2015). These systems are maintained by various forms of traditional ecological knowledge (TEK) (Berkes et al., 1994, 2000). TEK, based on empirical data, is a valuable source of data that enables novel scientific discoveries, and its reevaluation is anticipated to offer insights for addressing sustainability challenges (Ceriaco et al., 2011). Additionally, TEK has been reevaluated for future applications in sustainable agricultural practices (Altieri et al., 2015). In 2002, the Food and Agriculture Organization of the United Nations launched the Globally Important Agricultural Heritage Systems (GIAHS) program to preserve traditional agricultural values and knowledge for future generations (FAO, 2020a). The TEK data collected from GIAHS sites are anticipated to offer insights into achieving sustainable agricultural production in the future (GIAHS Book Editorial and Production Committee, 2015; UNU, 2011).

In this study, we focused on the folklore of the Nishi-Awa area, a mountainous region designated as a GIAHS site in 2018 because of its distinctive sloping land agriculture (FAO, 2020b; TTGAHPC, 2019). In this region, farmers traditionally cut wild plants that grow in the mountains and spread them in their fields as mulch (Hayashi, 2015; TTGAHPC, 2019). This mulching approach using plants is believed to prevent soil erosion, provide organic matter, and suppress weeds (Hayashi, 2015).

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In Japan, grasses, such as rice straw and silver grass (Miscanthus sinensis) are commonly used for plant mulching (Hadama et al., 1996; Hidehiro and Yoshinobu, 2014). In the Nishi-Awa area, where rice paddies are scarce, silver grass from mountains and fields has primarily been used for mulching (Hayashi, 2015). In contrast, in this region, it has long been said that Japanese knotweed (Fallopia japonica) is beneficial for growing solanaceous crops, and farmers have used it as mulch when cultivating solanaceous crops (Hayashi, 2015). Japanese knotweed, a perennial plant belonging to the Polygonaceae family, is a weed. Although the use of Japanese knotweed has been preserved through folklore and continues as a custom, the reason for its use remains unclear. To date, we have assessed the effectiveness of knotweed mulch on solanaceous crops, such as eggplant, tomato, and potato, and observed the following positive effects: 1) increased sugar content in eggplants and tomatoes (Hasegawa et al., 2018; Inagaki et al., 2019; Unno and Inagaki, 2019; Unno et al., 2020), 2) prevention of continuous crop challenges with tomatoes and potatoes (Unno and Inagaki, 2020; Hidehiro et al., 2021), and 3) induction of systemic acquired resistance in eggplants and reduction of disease damage (Hidehiro et al., 2021).

Although agricultural crops that have been cultivated for subsistence in mountainous areas are limited, a wide variety of crops are now grown commercially. Therefore, knotweed mulch may be effective on crops beyond the Solanaceae family, considering the diversity of the modern crops cultivated. Therefore, we assessed the effectiveness of knotweed mulch on commercial crops other than those of the Solanaceae family. Our research is beginning to confirm that this method effectively enhances the quality of certain crops beyond the Solanaceae family and prevents crop failure (Toyoda, unpublished data).

In contrast, organisms that are useful for agriculture, such as pest control, pollination, and organic matter decomposition, are called functional groups. Additionally, maintaining functional biodiversity, which preserves the types and quantities of functional groups, is crucial for sustainable agriculture (Ministry of Agriculture, Forestry, and Fisheries, Japan, 2012). Regarding the maintenance of functional groups, mulching with plants, such as rattail fescue (Vulpia myuros) or living mulch with wheat, increases the number of natural enemies (Ono, 2007; Doi et al., 2015; Tsuchida et al., 2015; Katayama et al., 2018). Therefore, mulching with plants is anticipated to increase the number of functional groups.

In this study, we report that knotweed mulching in vegetable cultivation increases the population of ground-dwelling carnivorous beetles, which are significant native natural enemies in agricultural ecosystems.

2. Materials and methods

2.1 Test Field

This study was conducted in a vegetable field and chestnut garden at the Center for Education and Research in Field Sciences, Shizuoka University (Kariyado, Fujieda city, Shizuoka Prefecture, Japan; 34°54'18.8" N, 138°16'19.7" E. Zucchini ('cv Green boat 2gou'), sweet corn ('cv Gold ruch'), and immature soybean ('cv Hakucho') were cultivated in the vegetable field. Zucchini and sweet corn were planted on 27th April 2023, with a spacing of 60 and 30 cm between plants, respectively. The soybean was planted on 1st June, with 30 cm spacing between plants. Basal fertilization with nitrogen (N), phosphorus (P), and potassium (K) was applied to all test plots at a rate of 14 kg/10a.

2.2 Experimental Plot

The three experiment plots include 1) mulching with Japanese knotweed (300 g/m^2) (JM plot), 2) mulching with rice straw (300 g/m^2) (RM plot), and no mulching (control plot). In the control plot, weeds were manually removed. Each plot had a ridge width of 1.3 m and ridge length of 7.5 m, with three replicates for each vegetable.

2.3 Pitfall Trap

The trap containers were plastic cups (88 mm in diameter and 97 mm in height) filled with 50 mL of 70 % ethanol to kill and preserve the captured insects. Nine traps (three per plot) were set between zucchini, corn, and immature soybean plants in each plot. After 2 days, the traps were collected, and the captured ground-dwelling arthropods were identified and counted. Pitfall trap surveys for each vegetable were conducted biweekly during the growing season.

2.4 Data Analysis

Data from this study were analyzed using Bell Curve for Excel 5.0 (Social Survey Research Information Co., Ltd.) software. Analysis of variance was performed, followed by Tukey's multiple range test, to identify significant differences among treatments with a probability of 95 % (α = 0.05).

3. Results

3.1 Species 0f Ground-Dwelling Organisms Captured in Pitfall Traps

In this survey, the following species were captured: carnivorous natural enemies (carnivorous beetles, spiders, staphylinoidea, earwigs, and centipedes), weed seed predators (herbivorous beetles [Harpalinae], crickets, mole crickets, millipedes, pill bugs, woodlice, slugs, and earthworms), and other omnivores (ants, click beetles, cockroaches, and gammarid amphipods). In terms of composition, most of the captured organisms were spiders and carnivorous ground beetles (Fig.1).

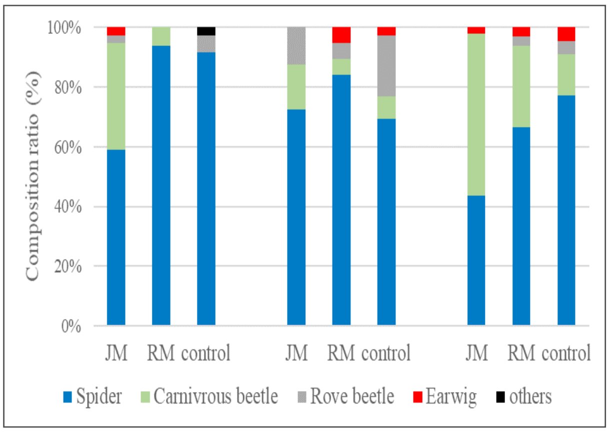

Figure.1 *Composition of ground-dwelling organisms captured in pit holes during the survey period.*

3.2 Effect of Mulch type on Abundance of Ground-Dwelling Spiders and Carnivorous Ground Beetles.

For the main functional organisms—ground-dwelling spiders and carnivorous ground beetles—the number of individuals per trap per time was calculated from the total values over the survey periods of three replicates, and analysis of variance and multiple range tests were performed (Fig. 2). No clear differences in spider populations were observed in zucchini, corn, or soybeans due to the different types of mulching. However, the number of carnivorous ground beetles was statistically significantly higher in the JM plots than in the RM and control plots for all crops, including zucchini, corn, and soybeans.

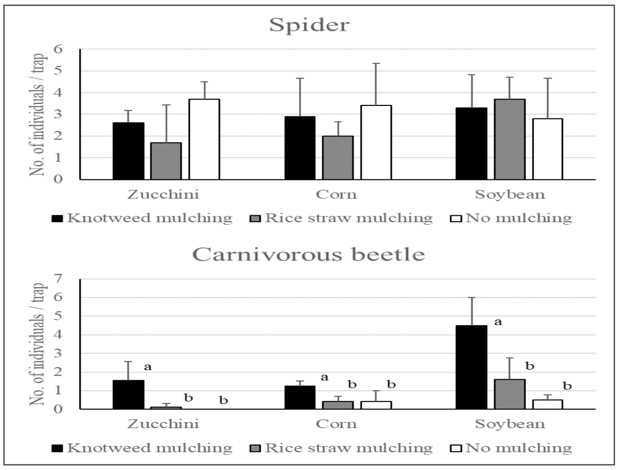

Figure.2 *Effect of mulch type on the abundance of ground-dwelling spiders and carnivorous ground beetles. Different letters indicate significant differences (P < 0.05, Tukey's multiple range test).*

3.3 Seasonal Alterations in Ground-Dwelling Spider Population

Fig. 3 illustrates the seasonal alterations in the population of ground-dwelling spiders. Under zucchini cultivation conditions, the number of adults increased gradually in all test plots, with similar seasonal trends in the JM, RM, and control plots (top of Figure 2).Under corn cultivation conditions, the number of adults in the JM and control plots increased in the June 8 survey, and then tended to decrease (middle of Figure 2).Under soybean cultivation conditions, the number of adult ground-dwelling spiders remained low in the JM, RM, and control plots. Soybean plots were characterized by a high number of larvae.

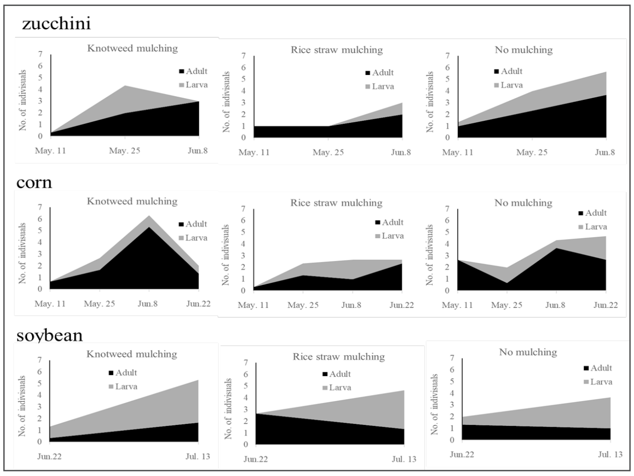

Figure. 3 *Seasonal alterations in the ground-dwelling spider populations.Upper zucchini, middle: corn, and below:soybean.*

3.4 Seasonal Alterations in Ground-Dwelling Carnivorous Beetle Population

Fig. 4 illustrates the seasonal alterations in the population of ground-dwelling carnivorous beetles (Pheropsophus jessoensis and Chlaenius pallipes). Under zucchini cultivation conditions, no ground-dwelling beetles were captured until 25th May in the JM plot (Fig. 2, upper). However, in a survey on 8th June, approximately 4.0 P. jessoensis and 0.7 C. pallipes were captured per trap in the JM plot. In contrast, almost no ground-dwelling beetles were captured in the RM and control plots.

Under corn cultivation conditions, no ground-dwelling beetles were captured in the JM plot until 25th May (Fig. 2, middle). In a survey on 8th June, 1.3 P. jessoensis beetles were caught per trap. In a survey on 22nd June, 1.3 adults and 1.0 larvae of P. jessoensis were captured. In contrast, fewer ground-

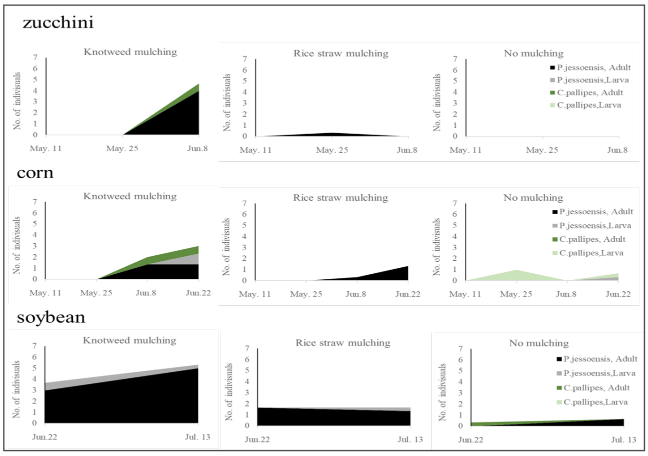

Figure.4 *Seasonal alterations in the ground-dwelling carnivorous beetle populations.Upper: zucchini, middle: corn, and below: soybean.*

dwelling carnivorous beetles were observed in the RM and control plots. Additionally, the number of C. pallipes captured was slightly higher in the JM plot than that in the RM and control plots.

Under soybean cultivation conditions, seasonal alterations in the population from June to July were small in each experimental area (Fig. 2, below). Throughout the survey period, the JM plot had a higher number of adult P. jessoensis than that of the other plots. In the JM plot, 0.7 larvae of P. jessoensis were captured on 22nd June. The RM plot recorded the highest number of ground-dwelling beetles after the JM plot, and the control plot had the lowest number of these beetles.

4. Discussion

Agricultural land preserves the biodiversity of agroecosystems. However, a high biodiversity can also result in increased levels of pests and weeds. Therefore, it is essential to consider the functional biodiversity of agroecosystems (Southwood and Way, 1970). Conserving and enhancing biodiversity in agricultural ecosystems is anticipated to conserve natural enemy populations and their food communities, thereby enhancing the control of pests by natural enemies, which is an ecosystem service (Altieri, 1994, 1999; Miguel, 1999). Functional biodiversity plays a crucial role in providing agroecosystem services (Altieri, 1999; Barberi, 2015; Camilla and Bàrberi, 2008; Duru et al., 2015; Miguel, 1999; Moonen and Bàrberi, 2008; Barberi, 2015; Rouphael, 2008). Consequently, researchers have extensively studied the conservation and enhancement of functional biodiversity (Southwood and Way, 1970; Laureto et al., 2015; Martin et al., 2019). Ground-dwelling spiders, specifically wolf spiders, are the most significant organisms in the functional biodiversity of agricultural ecosystems in Japan because they are the natural enemies of various insect pests (Ministry of Agriculture, Forestry, and Fisheries, Japan, 2012).

In this study, the number of spiders was not significantly affected by the presence or absence of plant mulch or plant mulch type. In contrast, the number of ground-dwelling carnivorous beetles increased when using Japanese knotweed covering materials. Because beetle larvae were observed in the areas covered with Japanese knotweed, this indicates that the Japanese knotweed mulch serves as a breeding source for ground beetles.

Ground-dwelling carnivorous beetles are significant natural enemies of insect pests in agricultural ecosystems (Sa'adah and Haryadi, 2021). Ground-dwelling carnivorous beetles feed on aphids (Chiverton, 1987; Holland et al., 1996; Sunderland et al., 1987; Sunderland and Vickerman, 1980) and prey on lepidopteran larvae, which are significant pests (Fuller, 1988).

Based on our previous studies, we recommended using Japanese knotweed as a crop cover to farmers outside the region. The farmers who have implemented this practice have reported a reduction in armyworm populations (Rural Culture Association, personal letter). Although further verification is needed, this effect may be because of an increase in the ground-dwelling carnivorous beetles caused by Japanese knotweed mulching.

In Europe, beetle banks—green areas within fields—have been proposed to provide habitats for ground-dwelling carnivores beetles (Colins et al., 2003; Fischer et al., 2010; Sotherton, 1995; Thomas et al.,1991). However, because the arable land area in Japan is smaller than that in Europe, it is challenging to use part of the farmland to create dedicated habitats. The use of Japanese knotweed as mulch material may be an effective method for conserving natural enemies.

The reason for the increase in ground-dwelling carnivorous beetles owing to Japanese knotweed mulching remains unclear. One hypothesis is that the gaps formed by the mulch create a suitable habitat for these beetles. Alternatively, a component of Japanese knotweed ground beetles may be attracting ground-dwelling carnivorous beetles, or there may be a stable food source other than pests. Understanding the factors by which the Japanese knotweed attracts ground-dwelling carnivorous beetles requires further research.

5. Conclusion

In recent years, functional biodiversity has garnered attention as an ecosystem service that enhances the natural control of insect pests by their natural enemies. This study assessed the effects of mulching with Japanese knotweed, a traditional agricultural method, on ground-dwelling organisms. The results demonstrated that this approach is effective in increasing the number of ground-dwelling carnivorous beetles, which are significant natural enemies of the Japanese knotweed.

However, this study was conducted in a limited area during a single cultivation period, and annual variations and differences in field conditions may exist. To generalize the effectiveness of Japanese knotweed mulch, it is necessary to accumulate data under diverse conditions.

Acknowledgements

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6. References

1. Altieri M. 2018. Biodiversity and pest management in agroecosystems. CRC Press.
2. Altieri M A. 1999. The ecological role of biodiversity in agroecosystems. In: Paoletti G M, (ed.). Invertebrate biodiversity as bioindicators of sustainable landscapes. Elsevier.
3. Altieri M A, Nicholls C I, Westwood G C. 2015. Agroecology: key concepts, principles and practices. Third World Network (TWN)-SCOLA. Jutaprint. Penang. Malaysia.
4. Barberi P. 2015. Functional biodiversity in organic systems: the way forward? Sustainable Agriculture Research, 4(3), 26–31.
5. Berkes F, Colding J, Folke C. 2000. Rediscover of traditional ecological knowledge as adaptive management. Ecological Applications, 10(5), 1251–1262.

6. Berkes F, Folke C, Gadgil M. (ed.). 1994. Traditional ecological knowledge, biodiversity, resilience and sustainability. In: biodiversity conservation. Netherlands, Dordrecht: Springer.

7. Ceriaco L M P, Marques M P, Madeira N C, et al. 2011. Folklore and traditional ecological knowledge of geckos in Southern Portugal: implications for conservation and science. Journal of ethnobiology and ethnomedicine, 7(26), 1–10.

8. Chiverton P A. 1987. Predation of Rhopalosiphum padi (Homoptera: Aphididae) by polyphagous predatory arthropods during the aphids' pre-peak period in spring barley. Annals of Applied Biology, 111(2), 257–269.

9. Duru M, Therond O, Martin G, et al. 2015. How to implement biodiversity-based agriculture to enhance ecosystem services: a review. Agronomy for Sustainable Development, 35, 1259–1281.

10. FAO (Food Agriculture Organization). 2020a. Globally important agricultural heritage systems (GIAHS). http://www.fao.org/giahs/en/. Viewed 6 Aug 2020.

11. FAO(Food Agriculture Organization).2020b.Globally important agricultural heritage systems (GIAHS). Nishi-Awa Steep Slope Land Agriculture System. http://www.fao.org/giahs/giahsaroundtheworld/designated-sites/asia-and-the-pacific/nishi-awa-steep-slope-land-agriculture-system/en/. Viewed 6 Aug 2020.

12. Fuller, B W. 1988. Predation by Calleida decora (F.) (Coleoptera: Carabidae) on velvetbean caterpillar (Lepidoptera: Noctuidae) in soybean. Journal of Economic Entomology, 81(1), 127–129.

13. GIAHS Book Editorial and Production Committee. 2015. Globally Important Agricultural Heritage Systems (GIAHS). Food, farming, and the future. IE-NO-HIKARI Association, Tokyo.

14. Hadama M, Kuroda Y, Kuroshima T, et al. 1996. Effects of fertilizer response and growth inhibition of weeds of Phragmites communis Trin mulching in rice [Oryza sativa] cropping. Tokushima Agricultural Experiment Station Reports, 32, 5–11.

15. Hasegawa K, Kubota S, Nakatani S, et al. 2018. Evaluation of traditional Japanese knotweed mulch farming in the Nishi-Awa steep slope-land agriculture system, Japan. Proceedings of the 5th conference of East Asia research association for agricultural heritage systems. Viewed 15 August 2024.

16. Hayashi H. 2015. Globally important agricultural heritage systems in Tsurugi-san area. Yoshinogawa, Japan: Tada Printing Co., Ltd.

17. Hidehiro I, Nahoko U, Takumi S et al. 2021. Effect of Japanese knotweed (Fallopia japonica) mulching on continuous potato cropping: Modern evaluation of traditional Japanese knotweed-mulch farming in Nishi-Awa steep slope land agriculture system, Japan. Journal of Resources and Ecology, 12(2), 254–259.

18. Hidehiro I, Sakiko K, Kana H, et al. 2021. Suppressive effects of traditional mulching using Japanese knotweed (Fallopia japonica) on Solanaceae crop diseases. Journal of Resource And Ecology, 12(6): 869–875.

19. Hidehiro I, Yoshinobu K. 2014. Assessment of GIAHS in Shizuoka: The traditional tea-grass integrated system. Journal of Resources and Ecology, 5(4), 398–401.

20. Holland J M, Thomas S R, Hewitt A. 1996. Some effects of polyphagous predators on an outbreak of cereal aphid (Sitobion avenae F.) and orange wheat blossom midge (Sitodoplosis mosellana Géhin). Agriculture Ecosystems & Environment, 59(3), 181–190.

21. Inagaki H, Hasegawa K, Kubota S, et al . 2019. Effects of Japanese knotweed mulch farming on cultivation of eggplants. Japanese Journal of Organic Agriculture Science, 11(1), 32–37.

22. Katayama H, Masui S, Doi M, et al. 2018: Presence of Neoseiulus californicus (Acari: Phytoseiidae) and suppression of citrus red mite Panonychus citri (Acari: Tetranychidae) density in mandarin orange orchards with rat's tail fescue ground cover. Annual Report Of the Kansai Plant Protection Society, 60, 39–45.

23. Laureto L M O, Cianciaruso M V, Samia D S M. 2015. Functional diversity: an overview of its history and applicability. Natureza & Conservação, 13(2), 112–116.

24. Martin E A, Dainese M, Clough Y, et al. 2019. The interplay of landscape composition and configuration: new pathways to manage functional biodiversity and agroecosystem services across Europe. Ecology Letters, 22(7), 1083–1094.

25. Miguel A A. 1999. The ecological role of biodiversity in agroecosystems. In: Invertebrate biodiversity as bioindicators of sustainable landscapes. practical use of invertebrates to assess sustainable land use.

26. Ministry of Agriculture, Forestry and Fisheries, National Institute for Agro-Environmental Sciences, & National Institute of Agrobiological Sciences. 2012. Indicator animals of functional agrobiodiversity: A survey and evaluation manual. http://www.niaes.affrc.go.jp/techdoc/shihyo/ Retrieved August 8, 2024.

27. Moonen A C, Bàrberi P. 2008. Functional biodiversity: An agroecosystem approach. Agriculture, Ecosystems & Environment, 127(1–2), 7–21.

28. Ono T, Kindokoro T. 2007. Control of foxglove aphid, Aulacorthum solani, in soybean using living mulch barley as banker plant. Annual Report Of the Society of Plant Protection of North Japan, 58, 99–105.

29. Rouphael S, Moonen A C, Bàrberi P, et al. 2008. Expression of on-farm functional biodiversity as affected by management and multi-scale agroecosystem disturbance. Landscape Management for Functional Biodiversity, 34, 85–88.

30. Sa'adah A, Haryadi N T. 2021. The effectiveness of weed as beetle bank against abundance of soil arthropods on corn (Zea mays L). The Journal of Experimental Life Science, 11(2), 54–59.

31. Southwood T R E. 1970. Ecological background to pest management. Concepts of pest management, 6–29.

32. Sunderland K D, Vickerman G P. 1980. Aphid feeding by some polyphagous predators in relation to aphid density in cereal fields. Journal of Applied Ecology, 17(2), 389–396.

33. Sunderland K D, Crook N E, Stacey D L, et al. 1987. A study of feeding by polyphagous predators on cereal aphids using ELISA and gut dissection. Journal of Applied Ecology, 24(3), 907–933.

34. Tsuchida Y, Doi M Tatara A, et al. 2015. Effects of alternative foods provided by living-mulch on the life history traits of the predatory bug, Geocoris proteus (Heteroptera: Geocoridae). Japanese Journal of Applied Entomology and Zoology, 59(1), 23–29.

35. TTGAHPC (Tokushima Tsurugisan Globally Agricultural Heritage Promotion Council). 2019. Globally recognized agriculture and living in Nishi-Awa. https://giahs-tokushima.jp/giahs/wp-content/uploads/2019/04/e4e9f93fa0bc3068507c3b479e3a0d91.pdf. Viewed 15 Aug 2024.

36. UNU (United Nations University). 2011. Japanese agricultural heritage systems recognized. https://ourworld.unu.edu/en/japanese-agricultural-heritage-systems-recognized. Viewed 6 Aug 2020.

37. Unno N, Inagaki H. 2019.Effects of pelletized Japanese knotweed on yields, quality of fruits, and disease suppression of tomato. In proceedings of the 20th conference of the Japanese society of organic agriculture science.