Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2016; 4(1): 36-41

Received: 18-11-2015
Accepted: 19-12-2015

Noor Ul Ane
Department of Zoology, University of Gujrat, Pakistan Hafiz Hayat Campus, jalalpur jattan road, Gujrat, Pakistan.

Mubashar Hussain
Department of Zoology, University of Gujrat, Pakistan Hafiz Hayat Campus, jalalpur jattan road, Gujrat, Pakistan.

Correspondence
Noor Ul Ane
Department of Zoology, University of Gujrat, Pakistan Hafiz Hayat Campus, jalalpur jattan road, Gujrat, Pakistan.

Diversity of insect pests in major rice growing areas of the world

Noor Ul Ane, Mubashar Hussain

Abstract
This study was conducted during June 2015 to September 2015 through a thorough review of a number of research papers, review papers and case studies that were published in journals of national and international repute. Major Rice growing countries of the world were studied in terms of pest diversity that they had in their rice fields that included China, Bangladesh, India, Philippines, Thailand and Sri Lanka. Additionally, some strategies that are being used by top growers to expand their economy through rice have also been discussed. This study aims to enlist major rice pests that are present in rice fields of all major rice growing countries of the world.

Keywords: rice producers, major pests of rice, diversity of rice pests.

Introduction
Vast cultivation of rice is commonly carried out worldwide as it is used as a basic diet by almost half of the world population especially eastern communities and it is by far the greatest cash crop. Major Rice growing countries include India, China, Bangladesh, Thailand, Myanmar, Philippines, Japan, Pakistan, USA, Indonesia, Korea and Vietnam. India and China produce 50% of rice in the world [1]. Rice cultivation has grown up to 158 ha out of which 90% production is being carried out in developing countries [2].

A wide area of land inhabited by the rice crops, tropical humid and dynamic environment and variety of growth stages in short time period have always been a great attraction by other species to adopt it as their niches [3]. It is occupied by various kinds of invertebrates that inhabit soil, water and vegetation area of rice ecosystems. Land-dwelling arthropod community largely comprises of insects and spiders. Terrestrial arthropods include rice pests, their natural enemies and non-rice pest insects that visit rice ecosystems for other concerns [4].

Over 800 species of insects in rice ecosystems have been reported worldwide. Out of these, 100 species attack rice while rest are considered as friendly insects [5]. Almost 20 insects are considered as rice pests of economic importance that include stem borers, gall midge, defoliators and vectors like leafhoppers and plant hoppers that cause direct damages and transmit various diseases [6]. The stem borer, brown plant hopper, gal midge and leaf hopper are among important pests in Southeast Asia and China while gall midge, brown plant hopper and yellow stem borer account for major rice yield losses in South Asia [7]. Most of rice plant parts are exposed to pest attack from period of sowing till harvest. Insects damage plant parts by chewing plant tissues, boring into stems or sucking fluid saps from stem and grains. Damages caused by insects disturb physiology of plants and result in to lower crop yield [8].

According to biodiversity productivity hypothesis, biodiversity plays significant role in maintaining a sustainable agronomic systems. In order to gain productive results, it is necessary to conserve diversity in agricultural systems. Practices like overuse of pesticides, monoculture, grazing, poor farming techniques etc. are posing threats to biodiversity associated with rice farming system [9].

Table 1: Major Rice Producers of the world.

Countries	Paddy Production (Million Tones)[10,11,12]			Avg. Loss/Profit %	Major Constraints in Production [10,11]
	2013	2014	2015*		
CHINA	202.8	206.4	208.0	+1.4	Harsh weather, pest outbreaks
INDIA	159.0	155.5	155.2	-3	Irregular monsoon, pests
INDONESIA	70.87	70.6	75.6	-0.9	Dry Weather, irrigation water
BANGLADESH	51.5	52.4	52.0	-1	Water supply, pests
VIETNAM	44.1	44.9	44.7	+2	Lower level of water in rivers
THAILAND	38.0	37.0	34.7	-3	Water scarcity, pests
PHILIPPINES	18.0	18.8	18.4	-0.4	Pest outbreaks
PAKISTAN	8.7	10.1	10.5	-1	Floods
SRI LANKA	4.3	3.6	4.1	+2	Precipitation shortfalls
NEPAL	5.05	4.6	4.6	-2	Natural Calamities

*FAO Forecast

Table 2: Major Pests of rice.

Scientific Name	Common Name	Order	Family
Recilia dorsalis	Zigzag leafhoppers	Hemiptera	Cicadellidae
Pelopidas mathias	Rice skipper	Lepidoptera	Hesperiidae
Nilaparvata lugens	Brown Plant hopper	Hemiptera	Delphacidae
Cicadella viridis	Green leaf hopper	Hemiptera	Cicadellidae
Caelifera spp.	Grasshopper	Orthoptera	Acrididae, Tettigoniidae
Orseolia oryzae	Rice gall midge	Diptera	Cecidomyiidae
Scirpophaga incertulas	Yellow Stem borer	Lepidoptera	Pyraustidae
Cnaphalocrocis medinalis	Rice leaf folder	Lepidoptera	Crambidae
Scotinophara coaractata	Rice black bug	Hemiptera	Pentatomidae
Baliothrips biformis	Rice thrips	Thysanoptera	Thripidae
Scapteriscus borellii	Mole cricket	Orthoptera	Gryllotalpidae
Lissorhoptrus oryzophilus	Rice root weevil	Coleoptera	Curculionidae
Oebalus pugnax	Rice bug	Hemiptera	Pentatomidae
Spodoptera frugiperda	Army worm	Lepidoptera	Noctuidae
Melanitis ismene	Green horned caterpillar	Lepidoptera	Sphingidae
Gryllus spp.	Field cricket	Orthoptera	Gryllidae
Brevennia rehi	Mealy bug	Hemiptera	Pseudococcidae
Hydrellia spp.	Rice whorl maggot	Diptera	Ephydridae
Dicladispa armigera	Rice hispa	Coleoptera	Chrysomelidae
Hysteroneura setariae	Root aphid	Hemiptera	Aphididae
Nymphula depunctalis	Rice case worm	Lepidoptera	Pyralidae

Biodiversity Status and Strategies against rice pests

China

Biodiversity was studied in rice fields of China and some modern approaches to deal with its ecological balance. There was a high abundance of biodiversity that was stated in paddies of China that included pests, natural enemies, weeds etc. 624 pest species and 1303 natural enemies have been reported. Some modern approaches as agrochemicals, better irrigation systems etc. are being used in China. An effort was thought to be needed to conserve biodiversity of Rice fields to conserve stable rice ecosystem [13].

The development and commercialization of insect resistant modified rice were studied in China. China prepared two varieties of Bt rice (*cry1Ab/Ac Bacillus thuringiensis*) for that she had received biosafety certificate after laboratory trials. These varieties being insect resistant provided China major advantages as increasing rice yields in coming years. Pests like plant hoppers and stem borers that were major and serious pests in China at previous times, now placed under primary pests. Primary and secondary pests in China include orders like Lepidoptera, Hemiptera, Diptera, Coleoptera, Orthoptera and Thysanoptera. 5 primary and 27 secondary pests have been reported. It was recommended that China should produce more genetically modified varieties in order to cope with pest problems that might restrain the crop yields [14].

China is largest producer and consumer of rice in the world. In past years, china had suffered major rice crop losses due to pest outbreaks. The trends of plant biotechnology in China are being highlighted. Genetically modified varieties have been produced and cultivated by farmers to gain good yield [15]. China has adopted hybrid rice varieties and on genomic levels, there are bright chances of transgenic varieties in future. It was recommended that there should be combined practices on hybrid and genomics to avoid use of chemicals and pest outbreaks [16].

The effects of nitrogen fertilizers on growth and reproduction of herbivores and major rice pests were considered. In Asian rice fields, it was studied that there was an excessive and long term use of nitrogen fertilizers. Herbivores and major insect pests like plant hoppers, leaf folder and stem borers flourished in excessive nitrogen supply to plants resulting in decline of crop yield. It was recommended to use normal quantity of nitrogen fertilizers to gain better crop yield and avoid more density of pests and chemicals [17].

India

Basmati Rice ecosystems of Uttar Pardesh, India were surveyed for checking arthropod diversity in rice fields. Insect pests that infested all parts of rice crops were noticed to be Yellow stem borer, striped rice stem borer, Leaf folder, Brown plant hopper, White-backed plant hopper, Rice gundhi bug, Rice hispa, Rice root weevil and Rice caseworm. Natural

predators of rice pests included dragon fly, spiders and praying mentis. Leaf folder and stem borers were observed to be at significant level during survey. It was suggested that biological control of rice pests should be preferred over chemical control as biological agents account for 60% mortalities of rice pests [18].

Grasshoppers fauna from rice fields of Uttar Pradesh, India in Rabi and Kharif seasons were monitored. 26 species of grasshoppers were reported and identified that belonged to 2 families, 8 sub-families and 12 tribes. Majority of diversity was shown by *Acrididae i.e.* 85%. *Pyrgomorphidae* also constituted diversity up to 15%. All the species of genera *Oxya*, *Hieroglyphus* and *Acrida* collected from field were observed consuming rice foliage. It was inferred that grasshoppers may be regarded as serious pests of rice as they can cause severe damages to rice crop at advance stages of growth [19].

Paddy and pulse fields in Bihar and Jharkhand, India were surveyed. High infestation of pests was noted. 34 species of Grasshoppers were being sampled from fields that belonged to 25 genera, 2 families, 10 subfamilies and 19 tribes. 26% diversity of grasshoppers belonged to Oedipodinae followed by Acridinae, Oxyinae, Gomphocerinae, Catantopinae, Cyrtacanthacridinae, Pyrgomorphinae, Tropidopolinae, and Hemiacridinae and with least diversity in Spathosterninae. It was concluded that there was a high infestation of grasshoppers in paddy and pulse fields of both states. It was thought to be considered as major pest and conventional methods were recommended to improve productivity of rice and pulses [20].

Rice fields of Uttar Pradesh were surveyed and major insect pests of rice crops were reported. Rice pests included Root feeders (termites, mole cricket, rice root weevil and rice water weevil), Stem borers (yellow stem borer, white stem borer, striped stem borer, dark headed stem borer, and pink stem borer), Leafhoppers and plant hoppers (white rice leafhopper, brown planthopper, whitebacked planthopper, the green planthopper, leafhopper), Defoliators (swarming caterpillar, oriental armyworm, rice grasshopper), Grain suckers such as rice earhead bug, and other pests such as rice gall midge, the rice leaf folders, the grain aphid, pentatomid bug, rice mealy bug, rice hispa, rice thrips, rice caseworm, whorl maggot flies, zigzag leafhopper and the common cutworm [21].

New species of thrips were reported from rice crops in Khasi Hills, Meghalaya. New species included *S. biformis, H. tenuipennis, B. indicus, H. ceylonicus, and A. sudanensis.* It was concluded that direct sampling of thrips was necessary to evaluate damage caused by this pests as its activity was not limited to growing season only [22].

Five species of thrips were collected from rice crops in Meghalaya. Species of thrips belonged to 2 families; Thripidae and Phlaeothripidae. *Stenchaetothrips biformis* was seen to be the dominant species comprising of 68% abundance followed by *Anaphothrips sudanensis* (17%), *Haplothrips ceylonicus* (10%), *Haplothrips tenuipennis* (3%) and *Bolacothrips indicus* (2%). Abundance of thrips was noted to be highest in July and lowest in November during each sampling period [23].

Bangladesh

A survey of rice insect pests was conducted in rice fields of Chittagong, Bangladesh during three growing seasons, Boro, Aus and Aman. 35 species belonging to 13 families and 30 genera were collected and identified. Four economically important orders of insects were Hemiptera, Orthoptera, Lepidoptera and Coleoptera. Highest insect density was seen during Boro season followed by Aman and Aus. Insect pests were abundant during seedling growth stage trailed by transplanting and flowering. Insect orders showed an increasing trend of population as Hemiptera being highest followed by Orthoptera, Lepidoptera and Coleoptera [8].

Present situation of plant hoppers was surveyed in Asian countries as China and Vietnam through questionnaires regarding agricultural practices, insecticidal usage, distribution and damages etc. from 1998-2007. Brown plant hopper (*Nilaparvata lugens*) and white backed plant hopper (*Sogatella furcifera*) were reported to be important rice pests in Asia. It was documented that Brown plant hoppers transmit viral diseases while white backed plant hopper indirectly damage rice crops immensely. The reasons for damage caused by plant hoppers was mentioned to be use of insecticides in agricultural fields [24].

Abundance and diversity of rice pests was studies in rice fields of coastal areas. Pests like yellow stem borer, rice bug, horned grasshopper, leaf folder, brown plant hopper etc. were noticed. It was studied that population dynamics of pests was related with kind of vegetation and growth stages of rice crops. Natural enemies included damsel flies and spiders that were recommended to be used in biological control of rice pests instead of chemicals [25].

Philippines

Arthropod diversity was studied in major irrigated rice fields of Leyte Philippines. Experimental fields included both chemically treated and untreated lands. Observed arthropods in abundance were leaf hoppers (*Cicadellidae*), plant hoppers (*Delphacidae*), bugs (*Pentatomidae*, *Scotinophara coarctata* and *Coreidae*), Coleoptera and grasshoppers (*Acrididae* and *Tettigoniidae*). It was perceived that abundance of arthropods in rice fields was associated with growth of the plants. Pests were absent during period of seedlings while they appeared and became abundant in early tillering stage till all durations of crop growth. Bugs and plant hoppers were abundant in early periods of crops in chemically treated sites. In untreated sites, leafhoppers were abundant during tillering stage while bugs were seen abundant during milking and maturity stage of crops. Spiders and ladybird beetles showed abundance from tillering stage till harvest. It was noticed that predators became abundant as pest population developed. As a whole, pests were high in number as compared to predators [26].

Pests and predators diversity of rice fields were studied in Philippines. Immigrant arthropods were also considered in study. During tillering stage, major insect pests were plant and leaf hoppers. It was seen that in untreated sites pests and predators were far higher in numbers as compared to treated sites. Pests showed abundance during tillering stage while predators were abundant in milking stage. Insect pests that moved from adjacent areas to rice fields included *Recilia dorsalis, Cofana spectra, Nephotettix* spp., *Nilaparvata lugens, and Eysarcoris* spp while *M. crocea, Agriocnemis* spp., *and M. vittaticollis* species immigrated as predators. It was concluded that pest density was followed by predators in abundance [27].

The morphological variations of rice black bug were highlighted from an outbreak population. Its reproductive potentials and phenotypic variations were considered to be serious after studying phenotypic makers. More information was suggested to be gathered to design proper control strategies [28].

Thailand

Organic rice fields of Thailand were being surveyed. 34 species of insects were observed. Out of these, 11 were pests, 17 predators and six parasites were found out. Pests included plant hoppers, leaf hoppers, bugs and others belonging to orders Lepidoptera, Thysanoptera (rice thrips) and Coleoptera. Predators belonged to Odonata, Orthoptera (grasshopper), Dermaptera, Coleoptera (ladybird beetle), Diptera and Araneae (spiders). It was observed that distribution patterns of insects differed with growth stages of rice plants [2].

The community structure of arthropods were classified in irrigated rice fields of Thailand according to their dominance and abundance. Order Hymenoptera (29 species) was prevalent, trailed by Homoptera (15 species), Coleoptera (11 species), and Diptera (9 species). The community structure of terrestrial arthropods in rice ecosystem included natural enemies (70 species) followed by insect pests (26 species), insect guests (5 species) and foragers (2 species). It was highlighted that there lies a deep relation between insect pests and their natural enemies. It was recommended that diversity of natural enemies of rice pests should be conserved and biological control should be favored over biocides [4].

Sri Lanka

Terrestrial arthropods were studied in Sri Lanka. 342 species of arthropods were detected. Out of which 282 species of insects were known belonging to 90 families and 17 orders. Most of the insects had their place in Hymenoptera consisting of bees and ants. Number of phytophagous pests was higher than predators. It was noted that insect number raised with crop growth but declined with pesticide usage. Correlation between pests and their natural enemies was seem to be maintained through minimum chemical use and manipulated weed cover [29].

Table 03: Distribution of rice pests in paddy fields of major rice producers

Family	Species	Distribution
Pentatomidae	*Scotinophara lurida*	Philippines [26, 27]
	Scotinophara coaractata	Bangladesh [8], Thailand [2]
	Leptocorisa oratorius	Sri Lanka [29]
	Nezara viridula	India [21], Bangladesh [8]
	Eysarcoris ventralis	Bangladesh [8]
	Antestia degenera	Bangladesh [8]
	Niphe elongata	China [14]
Delphacidae	*Nilaparvata lugens*	China [14], India [18, 21], Bangladesh [8, 25], Thailand [2], Philippines [26, 27], Sri Lanka [29]
	Sogatella furcifera	China [14], India [18, 21], Bangladesh [8], Thailand [2], Philippines [26, 27], Sri Lanka [29]
Cicadellidae	*Recilia dorsalis*	China [14], India [21], Bangladesh [8], Philippines [26, 27], Sri Lanka [29]
	Nephotettix virescens	China [14], India [21], Bangladesh [8], Thailand [2], Philippines [26, 27], Sri Lanka [29]
	Nephotettix nigropictus	India [21], Bangladesh [8], Philippines [26, 27], Sri Lanka [29]
	Cofana spectra	India [21], Sri Lanka [29]
	Tettigella spectra	Bangladesh [8]
	Thaia oryzivora	Bangladesh [8]
	Thaia rubigenosa	China [14]
Alydidae	*Leptocorisa spp.*	Thailand [2], Philippines [27]
Coreidae	*Pygomenida varipennis*	Philippines [27]
	Eysarcoris spp.	Philippines [27]
	Cletus spp.	Bangladesh [8], Philippines [26]
	Leptocorisa acuta	China [14], India [21], Bangladesh [8]
	Leptocorisa oratorius	India [18]
Acrididae	*Oxya hyla hyla*	India [19, 20], Philippines [26]
	Oxya fuscovittata	India [19, 20]
	Heteropternis banian	Philippines [26]
	Heteropternis respondens	India [19]
	Acrida exaltata	India [19, 20], Bangladesh [8], Sri Lanka [29]
	Acrida gigantea	India [19, 20]
	Acrotylus humbertianus	India [19]
	Acrotylus insubricus	India [20]
	Oxya velox	India [19, 20], Bangladesh [8]
	Oxya chinensis	China [14], Bangladesh [8]
	Hieroglyphus banian	India [18-21], Bangladesh [8]
	Hieroglyphus bettoni	Bangladesh [8]
	Hieroglyphus nigroleptius	India [19, 20]
	Atractomorpha spp.	Bangladesh [8]
	Acorypha glaucopsis	India [20]
	Tristia pulvinata	India [20]
	Tropidopola longicornis	India [20]

	Trilophidia annulata	India [19, 20]
	Oedaleus abruptus	India [19, 20]
	Oedaleus senegalensis	India [19, 20]
	Aiolopus simulatrix	India [19, 20]
	Aiolopus thalassanisus thalassanisus	India [19, 20]
	Phaloeba infumata	India [20]
	Truxalis viridifasciata	India [20]
	Oedipoda miniata	India [20]
	Locusta migratoria	India [20]
	Stenohippus mundus	India [20]
	Dociostaurus apicalis	India [20]
	Aulacobothrus luteipes	India [20]
	Oxya japonica japonica	India [19, 20]
	Spathosternum prasiniferum prasiniferum	India [19, 20]
Chrysomelidae	*Monolepta spp.*	Philippines [26]
	Dicladispa armigera	India [18], Bangladesh [8], Thailand [2]
Pyrgomorphidae	*Atractomorpha burri*	India [20], Philippines [26]
	Chrotogonus trachypterus	India [20]
Chironomidae	*Orseolia oryzae*	China [14], India [21], Sri Lanka [29]
Thripidae	*Stenchaetothrip biformis*	China [14], India [21, 22, 23], Thailand [2], Sri Lanka [29]
	Haplothrips tenuipennis	India [22, 23]
	Bolacothrips indicus	India [22, 23]
	Haplothrips ceylonicus	India [22, 23]
	Anaphothrips sudanensis	India [22, 23]
	Haplothrips aculeatus	China [14]
	Frankliniella intonsa	China [14]
Hesperiidae	*Parnara guttata*	China [14], Thailand [2]
	Pelopidas mathias	China [14], Bangladesh [8]
	Telicota augias	Bangladesh [8]
Noctuidae	*Sesamia inferens*	China [14], India, Thailand [2]
	Spodoptera litura	India [21]
	Spodoptera Mauritia	China [14], India [21]
	Mythimna separata	India [21], Sri Lanka
Pyralidae	*Nymphula depunctalis*	India [18, 21], Bangladesh [8], Thailand [2]
	Scirpophaga incertulas	China [14], India [18, 21], Bangladesh [8, 25]
	Scirpophaga innotata	India [21], Bangladesh [8]
	Scirpophaga auriflura	Bangladesh [8]
	Chilo polychrysus	India [21], Bangladesh [8]
	Paraponyx spp.	Bangladesh [8]
	Chilo suppressalis	China [14], India [18, 21]
	Cnaphalocrocis medinalis	China [14], India [18, 21], Sri Lanka [29]
	Marasmia exigua	India [21]
	Marasmia patnalis	India [21]
Ephydridae	*Hydrellia philippina*	India [21], Thailand [2]
	Hydrellia sinica	China [14]
Lygaeidae	*Pachybrachius spp.*	Bangladesh [8]
Tetrigidae	*Paratettix spp.*	Bangladesh [8]
Tettigoniidae	*Conocephalus longipennis*	Bangladesh [8, 25]
Gryllidae	*Euscyrtus concinnus*	Bangladesh [8]
Satyridae	*Melanitis ismene*	Bangladesh [8]
Cecidomyiidae	*Orseolia oryzae*	China [14], India [21]
Lophopidae	*Pyrilla perpusilla*	India [21]
Pseudococcidae	*Brevennia rehi*	India [21]
Hispidae	*Dicladispa armigera*	India [21]
Curculionidae	*Echinocnemus oryzae*	India [18]
	Lissorhoptrus oryzophilus	India [21]
Gryllotalpidae	*Gryllotalpa orientalis*	India [21]
Aphididae	*Hysteroneura setariae*	India [21]
Termitidae	*Microtermes obesi*	India [21]
	Odontotermes obesus	India [21]
	Odontotermes brunneus	India [21]
Pyraustidae	*Scirpophaga incertulas*	India [21]
Crambidae	*Cnaphalocrocis medinalis*	India [21]

Conclusion

There is plenty of diversity in paddy fields of the major rice producing countries. Greatest diversity of rice pests was seen to be in India and China because of their huge land area. Plant hoppers (Brown plant hopper and white-backed plant hopper) and leafhoppers (green leafhopper, zigzag leafhopper) were found to be widely distributed in paddy fields of major rice producers. These pests are responsible for huge economic losses to rice yields and different strategies are being developed against them to keep them at normal level. China being the biggest producer has developed enough genomic strategies to keep their rice pests below threshold level while other countries are still dependent upon conventional ways to control pests in their rice fields.

References

1. WASIM MP. A study of rice in the major growing countries of the world their growth instability and world share. Pakistan Economic and Social Review. 2002; 40(2):153-183.
2. Poolprasert P, Jongjitvimol T. Arthropod Communities Inhabiting Organic Rice Agro-ecosystem. International Conference on Agricultural, Ecological and Medical Sciences, 2014.
3. Edirisinghe Jp, Bambaradeniya Cnb. Rice Fields: An ecosystem rich in biodiversity. J Natn sci Foundation Sri Lanka. 2006; 34(2):57-59.
4. Thongphak D, Promdeesan K, Hanlaoedrit C. Diversity and Community Structure of Terrestrial Invertebrates in an Irrigated Rice Ecosystem. International Journal of Environmental and Rural Development. 2012; 3(1):68-71.
5. Pathak Md. Insect pests of rice and their control. IRRI. (ed.). Rice Production Manual. Los Baños: University of the Philippines, College of Agriculture in cooperation with the International Rice Research Institute. 1970, 171-198.
6. Pathak Md, Khan Zr. Insect Pest of Rice. Manila: International Rice Research Institute. 1994.
7. Sardesai N, Rajyashri Kr, Behura Sk, Nair S, Mohan M. Genetic, physiological and molecular interactions of rice and its major dipteran pest, gall midge. Plant Cell, Tissue and Organ Culture. 2001; 64:115-131.
8. Nasiruddin M, Roy Rc. Rice field insect pests during the rice growing seasons in two areas of hathazari, Chittagong. Bangladesh J Zool. 2012; 40(1):89-100.
9. Asghar M, Arshad M, Fiaz M, Suhail A, Sabir Am. A survey of rice farmers' farming practices posing threats to insect biodiversity of rice crop in the Punjab, Pakistan. International Journal of Biodiversity and Conservation. 2013; 5(10):647-654.
10. FAO. Rice Market Monitor. 2013; 16(4): 2-5.
11. FAO. Rice Market Monitor. 2014; 17(4): 1-4.
12. FAO. Rice Market Monitor. 2015; 18(2): 1-6.
13. Luo Y, Fu H, Traore S. Biodiversity Conservation in Rice Paddies in China: Toward Ecological Sustainability. Sustainability. 2014; 6:6107-6124.
14. Chen M, Shelton A, Ye G. Insect Resistant Genetically Modified Rice in China: From Research to Commercialization. Annu. Rev. Entomol. 2011; 56:81-101.
15. Huang J, Rozelle S, Pray C, Qang Q. Plant Biotechnology in China. SCIENCE. 2002; 295: 674-676.
16. Wang Y, Xue Y, Li J. Towards molecular breeding and improvement of rice in China. TRENDS in Plant Science. 2005; 10(12):610- 614.
17. Xian Lz, Ping Yx, Heong, Kl, Cui H. Effect of Nitrogen Fertilizer on Herbivores and Its Stimulation to Major Insect Pests in Rice. Rice Science. 2001; 14(1):56-66.
18. Gangwar Rk, Javeria S, Yadav K, Tyagi S, Singh R. Survey and surveillance of major insect-pests of basmati rice in western Uttar Pradesh (India). International Journal of Research in Applied, Natural and Social Sciences. 2015; 3(3):1-8.
19. Akhtar Mh, Usmani Mk, Nayeem Mr, Kumar H. Species Diversity and abundance of Grasshopper fauna (Orthoptera) in rice ecosystem. Annals of Biological Research. 2012; 3(5):2190-2193.
20. Usmani Mk, Nayeem Mr, Akhtar Mh. Field observations on the incidence of Grasshopper fauna (Orthoptera) as a pest of Paddy and pulses. European Journal of Experimental Biology. 2012; 2(5):1912-1917.
21. Singh Bb, Singh R. Major Rice insect pests in northeastern UP. Int. J. LifeSc. Bt & Pharm. 2014; 3(1):124-143.
22. Kharbangar M, Hajong Sr, Choudhry S. New records of thrips (Thysanoptera) species associated with rice in Khasi Hills, Meghalaya. Journal of Entomology and Zoology Studies. 2013; 1(6):100-104.
23. Kharbangar M, Choudhry S, Hajong Sr. Occurrence and Abundance of Thrips (Thysanoptera) Associated with Rice Crops from Meghalaya. International Journal of Research Studies in Biosciences. 2014; 2(5):1-7.
24. Catindig Jla, Arida Ga, Baehaki Se, Bentur Js, Cuong Lq, Norowi M *et al.* Situation of plant hoppers in Asia. Planthoppers: new threats to the sustainability of intensive rice production systems in Asia. Los Banos (Philippines): International Rice Research Institute. 2009, 191-220.
25. khan MMH. Abundance and diversity of insect pests and natural enemies in coastal rice habitat. Bangladesh j. entomol. 2013; 23(1):89-104.
26. Gangurde S. Aboveground arthropod pest and predator diversity in irrigated rice (*Oryza sativa L.*) production systems of the Philippines. Journal of Tropical Agriculture. 2007; 45(1-2):1-8.
27. Gangurde S, Martin K, Goeltenboth F, Sauerborn J, Ceniza Mjc. Abundance dynamics of selected arthropods in relationship with rice plant growth, pests and their natural enemies. TROPENTAG. Conference on International Agricultural Research for Development, 2007
28. Torres Maj, Figuerus Gs, Luceno Ajm, Patiluna Mle, Manting Mme, Rampola Rb *et al.* Describing phenotypic diversity in an outbreak population of Rice Black Bugs from Balangao, Diplahan, Zamboanga Sibugay, Philippines, using principal component analysis and K-means clustering of morphological attributes. AES Bioflux. 2013; 5(1):15-22.
29. Bambaradeneya Cnb, Edirisinghe Jp. Composition, structure and dynamics of arthropod communities in a rice agro-ecosystem. Cey. J Sci (Bio. Sci.). 2008; 37(1):23-48.