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REVIEW ON EFFECT OF RUSSIAN WHEAT APHIDS (RWA) DIURAPHIS NOXIA (MORDVILKO, HEMIPTERA: APHIDIDAE) AND ITS MANAGEMENT ON BARLEY PRODUCTION IN ETHIOPIA.

Geteneh Mitku*

Ethiopian Institute of Agricultural Research, Debre Zeit Center, P. O. Box 32, Debre Zeit, Ethiopia.

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***Corresponding Author**
Geteneh Mitku
Ethiopian Institute of Agricultural Research, Debre Zeit Center, P. O. Box 32, Debre Zeit, Ethiopia.

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the most important staple food crops grown in the highlands of Ethiopia and believed to have been cultivated in Ethiopia as early as 3000BC (Hailu and Leur, 1996). In the main season (*Meher,* Amharic version), it is the fifth major cereal crop after maize, sorghum, tef and wheat in terms of area coverage and total production (CSA, 2013). RWA is a significant pest problem in many areas in the world (Anna-Maria *et al.*, 2003). In the *Belg* season, many farmers in Ethiopia have stopped growing barley. It is major insect that reduces barley yields, and it has a worldwide distribution including the Middle East, USA, South Africa, and Ethiopia. In Ethiopia infestations are particularly serious in the highlands where the climate is cool and barley is sown during late April to early May.

In Ethiopia, more than 38 species of insect pests have been reported to affect barley. Of these eight are aphid species; the most important is the Russian Wheat Aphid (RWA) (*Diuraphis noxia* Mordvilko Homoptera: Aphididae) (Adugna and Kemal, 1985). RWA was first reported in the Wukro (Atsbi) and Adigrat regions of northern Ethiopia in 1972/73 and western Wello region of northwestern Ethiopia in 1974 (Adugna and Tesema, 1987).

The Russian wheat aphid (RWA), *Diuraphis noxia* (Mordvilko), is a small, lime-green and has a distinctive football-shaped body. The overwintering takes place as parthenogenetic females and different instar nymphs on individual wheat, barley and other grasses left in the field (Archer *et al.*, 1998). RWA is the major insect that reduces yield of barley and has worldwide distribution including the Middle East, U.S.A., South Africa, and Ethiopia (Girma *et al*., 1993).

From the identified aphid species, *S. ramulensis* and *Tetraneura* spp. occurred less frequently than the other species in the collected samples *S. ramulensis* was recorded only from Awassa, while *Tetraneura* spp. From Ziway There is diverse cropping system at both the study locations, where maize, beans, pea, cabbage, onion, tomato, wheat, teff, barley and potato were the major crops found around the pepper fields (Simon *et al.*, 2009).

The recommended method for control of RWA includes application of insecticide, biological control, cultural practice, use of resistance variety and integrated insect pest management. Ethiopian condition, in the RWA hot spots of North Shewa farmers have adopted early maturing varieties of barley by planting them in late June. This delayed sowing helps the crop to escape much pest damage; however, as observed, the yields decrease correspondingly (Bayeh and Tadesse, 1996). In the highlands of Ethiopia, most farmers live at a subsistence level and so they cannot afford the use of insecticides against The Russian wheat aphid, although a number of seed dressings and sprays have been identified (IAR, 1984). Less expensive contact insecticides have not proved to be effective due to the insect's habit of secluding itself in the rolled leaves (Webster, 1990). Biological control is difficult as the efficiency of most of the existing natural enemies is low at the early stage of the crop (Adugna and Tesema, 1987). The use of resistant cultivars is the ideal management option for *D. noxia* (Robinson, 1992). *D. noxia*-resistant barley lines were also identified in Ethiopia. Biotypic variation can threaten the durability of host plant resistance to insects (Saxena and Barrion, 1987), and biotypes develop as a result of selection from the parental population in response to exposure to resistant cultivars or other pressures.

Therefore, objective of this review is to review the Russian wheat aphid effect, status and its management on barley in Ethiopia.

2. REVIEW

2.1 Russian Wheat Aphid Status and Effect on Barley in Ethiopia

2.1.1 Biology of Russian wheat aphid

The RWA reproduces almost exclusively by parthenogenesis; very few males have been found (Burnett *et al.,* 1991). Two forms of Russian wheat aphid (RWA) are found in the High Plains during the year: a wingless female and a winged female. The RWA is probably anholocyclic in Ethiopia as there is no severe cold season that may require sexual reproduction (Smith *et al.*, 2004). RWA spends its entire life cycle on grains and grasses. Throughout the year, on depleting its food source, or under adverse environmental conditions or overcrowding may stimulate the production of viviparous winged females, which are easily dispersed on wind currents. After a short feeding period on new plants, these females begin giving birth to wingless living young at a rate of 4-5 per day for about four weeks (Jay and Thomas, 1989). Asexually reproducing populations of RWA are all female and adults give birth to live nymphs. After the fourth moult, aphids develop into either wingless (apterous) or winged (alate) adults. Wingless adults have a higher reproductive capacity and can produce 4-5 nymphs per day for a 3-4-week period (Plant Health Australiya, 2012).

2.1.2 Biotype status of Russian wheat aphid (RWA) in Ethiopia

RWA biotypes generally show phenotypic differences in terms of reproduction, population increase and differential virulence on different resistant host genotypes (Malinga, 2007). Biotypes of RWA started to be noticed in 1989 when RWAs in Syria and Kyrgiz were found to be virulent to the Dn4 resistance gene in wheat (Puterka, 1992). (Haley *et al*., 2004) identified a virulent biotype in Colorado that could acutely damage wheat with any one of the eight of the nine Diuraphis noxia (Dn) resistance genes, with the exception of Dn7 (from nine Dn resistant gene), and designated this biotype as Biotype 2. The other Russian wheat aphid biotypes, all characterized in the USA, Biotype 3, Biotype 4 and Biotype 5, have the ability to differentially damage wheat with Dn1 to Dn9 resistance genes in wheat (Burd, 2006), whereas RWASA1 and RWASA 2 have been characterized in South Africa (Jimoh, 2012).

Reproductive decisions are based on plant cues and cues based on reproductive decisions, which may be an additional determinant of fitness (Powell and Hardie, 2000) and, thus, a basis for biotyping RWA populations. Female insects maximize species fitness by oviposition on high quality hosts (Jaenike, 1981). The ability to locate a suitable host for colonization and a corresponding superior reproductive ability and survival are outstanding features for ecologically-successful pests. Ecologically-successful biotypes would have shorter generation times, be prolific and live longer on a host, making these phenotypic markers possible effective indicators of biotypes. Biotypic status of five Ethiopian RWA strains was determined using several Ethiopian barley lines and six wheat lines containing different RWA resistance genes, no biotypic variation was found among the five Ethiopian RWA clones (Shufran *et al*., 1997). Plants containing *Dn4* are susceptible to the Ethiopian RWA clone taking the leaf rolling parameter into consideration.

The Ethiopian biotype seems different from the American biotype but similar to the Czech RWA biotype taking the results of *Dn4* reported by Smith (pers. comm.). Similarly, Puterka *et al*. (1992) identified distinct RWA biotypes from the former USSR and Turkey and Basky *et al*. (2001) observed differences in virulence between South African and Hungarian RWA populations on plants containing *Dn4,* as well as *Dn1, Dn2*, and *Dn5*.

2.1.3 Distribution of Russian wheat aphid

The present RWA situation in Ethiopia is abundant in certain highland places, the aphid population increases during the period when there is moisture stress (Bayeh, *et al.,* 2011). RWA infestation often starts at the early seedling growth stage, and as damage progresses the aphid pressure increases and the infestation may even persist after heading and result in severe crop damage or total crop failure. This is mainly the case in the *Belg* season (February to May), which has low rainfall.

2.1.4 Population dynamics of Russian Wheat aphid in Ethiopia

Studying temporal population fluctuations and spatial distribution pattern of a pest is the first step to designing a sampling method. Numerous factors can cause fluctuations in aphid numbers. Factors such as weather, farming practice, plant age, emigration, disease, parasites, and predators have been discussed by many workers (Pass and Parr, 1971). There are few studies on the population dynamics of RWA on barley in Ethiopia that are essential to design appropriate management practices. The population dynamics of RWA was studied at Chacha, which is the most important area where RWA is an endemic problem. The result then shows that a very low level, causing no significant damage when the rainfall becomes more frequent (Adugna, 1984). Similar results were obtained in North Wollo (at Estayesh) and South Wollo (at Gimba) (SIARC, 1996). This implies that RWA population is dynamic, due to different factor like rain fail fluctuation.

2.1.5 Host range of Russian wheat aphid

Russian wheat aphids remain on small grains or grasses all year long, and never move to a woody host as with other aphids. Nymphs and adults feed on plant phloem with a piercing-sucking stylet. Russian wheat aphids prefer to feed on foliage and grain spikes of actively growing plants. While feeding, these aphids can transmit a toxin that causes discoloration and distortion of the plant (Jay, 2008). A variety of wild grasses can serve as host plants for the Russian wheat aphid and may be important for aphid survival when cereal crops such as wheat and barley are not available. In order to persist in a region, Russian wheat aphid must have host plants year-round. Cool-season grasses important for this insect include wheat grasses, brome grasses, wild ryes and jointed go at grass (Michaud and Phillip, 2005).

In Ethiopia host range survey conducted in a part of the Amhara region identified 16 cultivated and wild grass species that host the RWA (Amare and Addisu, 1998). The results of host preference studies on six grass species conducted in field and pot experiments showed that broom grass, wheat and barley were the hosts most preferred, and oat (cultivated and wild) and teff were less preferred. Similar results were obtained earlier at Holetta (Taedesse and Gebremedhin, 1989).

2.1.6 Ecology Requirement Russian Wheat Aphids

The geographical range of Russian Wheat Aphids, D. noxia (particularly the areas where it is a pest) is restricted to regions of low rainfall. Furthermore, even in areas with low rainfall, D. noxia is rarely a problem in irrigated cereals, and populations decline after heavy rainfall. These observations suggest that precipitation and/or humidity may directly or indirectly reduce survival or reproduction of D. noxia (www.cabi.org/isc).

In Ethiopia, *D. noxia* has been a serious barley pest for about two decades (Mulatu and Gebremedhin, 1996). Currently, *D. noxia* is a major pest in all barley growing regions of Ethiopia, especially those at altitudes above 2,500 m a.s.l. where barley is the major food crop and is cultivated throughout the year.

2.1.7 Russian wheat aphid effect on barley yield loss

Yield losses due to RWA are severe with individual plant losses as high as 90% possible (Du Toit and Walters, 1984). Robinson (1992) recorded crop losses of 68% in Ethiopia and 35-60% in South Africa for wheat. This insect generally causes yield losses of 41-79 % in barley and up to 86% in wheat in Ethiopia (Miller and Adugna, 1988). Typical white, yellow and purple to reddish purple longitudinal streaks occur on the leaves of plants infested with RWA. The aphids are found mainly on the adaxial surface of the newest growth, in the axils of leaves or within rolled leaves. Heavy infestations in young plants cause the tillers to become prostrate, while heavy infestations in later growth stages cause the ears to become trapped in the rolled flag leaf (Walters *et al*., 1980). RWA infestation leads to a drastic reduction in chlorophyll content (Kruger and Hewitt, 1984) and reduced photosynthetic ability (Fouche *et al*., 1984) which, when combined with the characteristic leaf rolling that occurs, causes a considerable loss of effective leaf area of susceptible plants. The Russian Wheat Aphid can also be damaging as a vector of plant pathogenic viruses including Barley Yellow Dwarf Virus, Barley Mosaic Virus, and Sugarcane Mosaic Virus (Damsteegt *et al.*, 1992).

The Russian wheat aphid causes severe damage to barley, in the highlands of Ethiopia. Cereals in Ethiopia are grown under divers vegetation, which have profound effects on diseases and populations of arthropod pests and natural enemies (Gordon *et al*., 1995).

Table 1: Barley grain yield losses caused by the Russian Wheat aphid in different parts of Ethiopia.

Area	Location	Year of assessment	Recorded grain losses (%)
South Gonder	Lay Gayint	1995 and 1996	38.3
North Shewa	Chacha	1995 and 1996	86
North Shewa	Degem	1995 and 1996	68
North Wollo	Estaysh	1995 and 1996	35
North Wollo	Debresina	1995 and 1996	26
North Wollo	Hamisit	1995 and 1996	14
North Wollo	Kon	1995 and 1996	21
South Wollo	Gimba	1995 and 1996	62
Tigray	Alajie	1999 and 2000	40.30

Sources (Bayeh, *et al.*, 2011a).

2.2 Management Option

There are different kinds of recommended control option for RWA on barley. When natural enemies and host-plant resistance fail, producers must rely on insecticides to limit aphid damage. Deciding when to treat for Russian wheat aphids is based on economic thresholds. The economic threshold is where the damage from the aphid equals the cost of control. In order to support sustainable crop production, it is important to develop alternative methods of pest control.

2.2.1 Chemical control

Use of insecticides is one of control options for RWA. There are different types of chemicals registered in Ethiopia as a control option of Russian wheat aphid, Dimethoate is popular and mostly used insecticide to control RWA. To check insecticide efficacy there were verification trial, verification of the spray insecticide Dimethoate (Ethiothoate) 40% EC for the control of RWA on barley was conducted at Chacha and Cheki with supplemental irrigation during the *Belg* season of 2003. Two sprayings of these insecticides at a rate of 1.5 L/ha effectively controlled RWA on barley and gave a marginal net benefit of 437.95 and 446.95 birr/ha when the price of the chemical is taken at market and company prices, respectively (DBARC, 2003). Rolled leaves are a common damage symptom indicating host plant susceptibility. A characteristic behavior of *D. noxia* is to feed and develop inside the rolled leaf whorl confining insecticide options to active ingredients with systemic action able to penetrate the rolled leaf. Systemic insecticides containing disulfuton, dimethoate and demeton-S-methyl; or vapour-action insecticides with chlorpyriphos or parathion have proven to be effective against RWA (Robert, 2008). Tightly rolled leaves make spraying less effective, and interfere in biological control (Robinson, 1992).

In the highlands of Ethiopia, most farmers live at a subsistence level and so they cannot afford the use of insecticides against RWA. Due to the subsistence nature of the farming system Ethiopia, farmers have not adopted the use of insecticides.

Table 2. Partial budget analysis for the three insecticides and untreated local barley seed at Cheki and Chacha under irrigation, 1999.

Parameter Cruiser	70 WP Apron Star	42 DS Gaucho	70 WP Untreated
Average grain yield (kg/ha) 1124	1008	1188	926
Average straw yield (kg/ha) 2777	1828	1609	1870
Gross benefit (Birr/ha) 3359	2747	3020	2600
Total costs that vary at 10% pm 292	705	1187	219
Total costs that vary at 15% pm 294	721	1218	219
Cost of labour (Birr/ha) 12	12	12	–
Price of barley seed (Birr/ha) 219	219	219	219
Price of insecticide at 10% pm 61	474	959	0
Price of insecticide at 15% pm 63	490	990	0
Net benefit (Birr/ha) at 10% pm 3067	2042	1833	2379
Net benefit (Birr/ha) at 15% pm 3065	2026	1802	2379
Marginal cost (Birr/ha) at 15% pm 75	502	999	–
Marginal net benefit (Birr/ha) at 15% pm 686	(353)	(577)	–
MRR (%) over untreated barley 915			

Source (Bayeh *et al*., 2011b)

Price of the insecticides is estimated after importer profit margins of 10% and 15% are included at Addis Ababa. Prices of Cruiser 70 WP, Apron Star and Gaucho were 672, 759 and 3170 Birr/kg, respectively. Estimated price of local barley seed at planting is taken to be 1.75 Birr/kg. 80% for farmers to obtain an acceptable MRR. In areas such as Chacha, where RWA is a serious and constant problem for barley production during the *Belg* and under irrigation, it was recommended that seed dressing insecticides be used. Similar results were obtained at Gimba (SiARC, 1997).

2.2.2 Biological control

There are three different type of biological approach; Classical, inundutive and conservation biological control approach. Classical biological control consists of the introduction of an ‘‘exotic’’ natural enemy (pathogen, predator and parasitoid) for the regulation of a pest species, itself usually introduced accidentally outside of its natural distribution (Caltagirone, 1981). Inundative releases of millions of parasitoids to control a host is a more recent practice that concerns mainly protected crops. Parasitoid, because aphids have developed resistance to several insecticides (Devonshire *et al*., 1998) and because pesticide regulations are now stricter, biological control alternatives are increasingly investigated. Predators, the aphid is the template that influences ecological interactions, including predation, at the upper trophic level. Spiders, coccinellids, lacewings, anthocorids, nabids, predatory midges, syrphid flies, carabids, staphylinids and ants are major components of the predatory guild associated with aphid colonies (Sunderland, 1988).

In Ethiopia, the ssp. *tredecimsignata* has existed for a long time. Based on surveys in central and northern highlands of Ethiopia, Haile and Megenasa (1987) reported three species of parasitoids associated with *D. noxia,* including *A. colemani, A. hortensis* (Marshall) and *A. setiger* (Mack). The most likely reason for discrepancy could be climate changes. The report made by Haile and Megenasa (1987) was based on surveys from diverse ecological zones, whereas the present investigation was limited to the central highlands. Moreover, it has been observed during this study that coccinellids occurred often in great numbers towards the end of the season, at which time *D. noxia* had already reached peak numbers and were forming alates and leaving the plants.

2.2.3 Resistant varieties

Traditionally, long-term sustainable management of RWA relies on host plant resistance (HPR), beside cultural practice varietal resistance is an important phenomenon in insect pest management. From a practical point of view, resistance is the ability of certain varieties to produce larger yield of good quality than other varieties at the same initial level of infestation and under similar environmental conditions (Rizwan, 2010). Resistant varieties are the most effective means of RWA management and should be used if there is a variety available that does well in a given area. Russian wheat aphid resistant varieties may still be used if they perform well in a given area, however, they likely will not provide any useful resistance (Frank, 2006).

In Ethiopia, in spite of the increasing importance of RWA on barley production in Ethiopia, only few works have been done in the area of varietal host resistance. Host plant resistance is an important avenue of pest management, and it is one of the favored control tactics for the cereal aphids (Robinson, 1992). The use of host plant resistance in Ethiopian situation is often limited to avoidance of susceptible barley varieties and the subsequent shift to early maturing varieties by farmers. The only barley variety so far identified by Holetta Agricultural Research Center as resistant to RWA is a barley line 3296-15 (Tadele, 2015).

Resistance mechanism, host plant resistance, all-important RWA management strategy is not effective in some instances due to the evolution of RWA biotypes (Basky, 2003). These are variants of the pest that are able to overcome host plant resistance mechanisms, especially antibiosis and antixenosis (Bush and Diehl, 1984).

2.2.4 Integrated Pest Management (IPM)

IPM is an ecologically sound, environmentally friendly, and economically affordable pest management approach that employs optimum blends of control measures to keep pest numbers below economic level. According to USAID (2003) some of the important attributes of IPM are that: It is farmer-based, knowledge-intensive, encourages natural control, aims to 'prevent' pest problems, permits safer pesticide, uses indigenous techniques, promotes safer techniques, focuses on host plant resistance.

Subsistence farmers in Ethiopia, and elsewhere in Africa, traditionally use a combination of several pest management practices (such as cultural control, habitat manipulation, mechanical and physical control, natural biological control, host plant resistance, use of locally available materials) such that regular insect pest outbreaks of the magnitude experienced in commercial agriculture is rare (Abate *et al*., 2000). Use of some cultural practices, particularly intercropping and methods encouraging habitat diversity, create an environment conducive to natural enemies (parasitoids and predators) and can be considered a type of natural biological control. Thus, the small-scale farmer is a general practitioner of IPM.

The Russian wheat aphid is the major insect that reduces barley yields, and it has a worldwide distribution including the Middle East, USA, South Africa, and Ethiopia. It is therefore necessary to monitor the biotypic status of *D. noxia* in Ethiopia as a component of a comprehensive integrated pest management approach (Alemu *et al*., 2014). Grassland management and crop rotation can go some way to reoucing reservoirs of the aphid. The use of resistant or tolerant host plants, as well as effective, economical and available seed dressings or spray formulations of insecticides, are possibilities in the management of RWA.

Cultural control, including timely sowing and crop hygiene, is the major control measure (Ferdu Azerefegne, 1991).

Under small-scale farming conditions, the following are usable technologies for management of RWA (Bayeh *et al.,* 2011).

1. Clearing broom grass in and around barley fields is a good cultural practice for reducing damage by RWA.
2. Early planting of barley in the *Belg* season in North Wollo.
3. Promoting the use of 3296-15, a proven RWA-resistant cultivar.
4. Using Cruiser 70 WP, Furathicarb 400 CS and Imidacloprid 70 WS at rates of 75, 74 and 88.2 g Per 100 kg barley seed as effective seed treatments against RWA.
5. Using Dimethoate 40% EC at a rate of 1.5 L/ha to effectively control RWA on barley.
6. Using Pirimiphos-methyl 50% EC at 1 L/ha to effectively control RWA on barley.
7. Early sowing combined with a one-off spraying of Pirimiphos-methyl 50% EC to effectively control RWA on barley.
8. Combining a tolerant line (3296-15) with dimethoate, and complementing the Spraying with

fermented cow urine or tobacco extract, to effectively control the RWA.

The aphid problem can be tackled with application of commonly used insecticides, but the drawback lies with their indiscriminate use resulting in problems of health hazards, environmental pollution and development of resistance in insects against insecticides Therefore it is advised that such varieties should be screened out which are resistant against aphid attack. By using chemical insecticides natural balance also become disturbed, especially between predators and parasites. Therefore, it is advised that biological control should be practiced to avoid all these problems.

2.2.5 Cultural control

Cultural control insect pests by manipulating the field environment making it unfavorable for the pests. This affects the pest population by increasing the mortality or adversely affecting the natural reproduction; or promoting the natural enemies of the pest species (Hill, 1993). Polyculture or mixed cropping is one of the cultural practices that have received much emphasis in recent agro-ecological studies. These cropping systems influence the abundance, diversity and relative importance of pests and their natural enemies and the yield performance of component crops. Commonly, pest populations are lower in mixed-crop as compared to monocrop system (Ogenga-Latigo *et al*., 1993).

2.2.6 Sowing date trial

Cultural practices may play a key role in minimizing RWA damage and preventing early- season infestations. A sowing date experiment conducted at Gimba and Gashena, in North Wollo, during the *Belg* season of 1996. Delayed planting increased aphid infestation and decreased grain and biomass yield, indicating the importance of early planting as a cultural control of RWA (Adane, 1998). Infestations are particularly serious in the highlands. The climate there is cool and barley is sown during late April to early May. Farmers prefer the late barley varieties as they give higher yields. The *Meher* season (June to October) is the most important season for barley production across the country. Early planting in May was abandoned by farmers in places such as the eastern parts of South Gonder, Wollo and North Shewa, due to a dry period in early June. The effect of N fertilization on the population of RWA was studied during the 1995 crop season in the highlands of Maichew.

The present RWA situation in Ethiopia is that the pest is abundant and serious in the highlands when the climate is cool. RWA infestation often starts at the early seedling growth stage, and as damage progresses the aphid pressure increases and the infestation may even persist after heading resulted in severe crop damage or total crop failure. This case is mainly pronounced in the *Belg* season (February to May), which has low rainfall. Early planting in May was abandoned by farmers in places such as the eastern parts of South Gonder, Wollo, North Shewa and South Tigray due to a dry period in early June.

2.2.7 Effect of fertilizer on population of RWA

Synthetic fertilizers, particularly nitrogen, have been found to increase the occurrence of pests, particularly sap feeding insects (Bi *et al*., 2001). Fertilizer effects on host plant morphological characteristics such as increased leaf growth have also been shown to influence pest infestation (Honek, 1991). High level of Nitrogen favors the attack of aphid, the application of Nitrogen alone increased the aphid infestation, whereas Nitrogen and phosphorous in combination suppressed the aphid attack (Khattak *et al*., 1996).

In Ethiopia, effect of N fertilization on the population of RWA was studied during the 1995 crop season in the highlands of Maichew, Ethiopia. Results indicated that there was no significant variation between the different levels of fertilizers and the control. However, 100 kg/ha urea and 100 kg/ha DAP treatment combinations showed a relatively high level of aphid population (MeARC, 1997).

2.2.8 Botanicals control

Botanicals /plant extracts/ are among natural pesticides, many plants are being investigated for their insecticidal attributes and possible application to control insect pests on food crops in this regard, some works that showed botanical pesticide properties of some plant species on storage and field crop pests have been reported in Ethiopia (Bayeh and Tadesse, 2000). Higher plants contain a wide range of secondary metabolites like flavonoids essential oils, phenols, tannin, steroids and alkaloids. Such plant-derived chemical may be exploited for their different biological properties (Dubey *et al*., 2008).

In Ethiopia, different plant crude extract evaluated to control different insect pest by different researchers. Evaluation of some selected village-available botanicals for the control of RWA conducted by the Sirinka Research Centre in 1998 showed that spraying tobacco and fermented cow urine resulted in good pest control and there was more than a 50% grain yield advantage in barley over the untreated check (SiARC, 1998). In Ethiopia RWA control on barley depend on the synthetic chemical. But barley is a major food staple and use of any chemical insecticide will lead to the health hazards and entry of various chemicals into food chain, there for botanical control should be encouraged.

3. SUMMARY AND CONCLUSION

Even though barley is one of important crop in Ethiopia, most farmers totally constrained by the damage of Russian wheat aphid, until recently, there were no enough improved barley varieties in the hands of farmers. Hence, farmers have been growing low-yielding local cultivars such as ‘Aruso’, Burtuji, Baltícha and Senefkolo. According to current research result effect of

Russian wheat aphid is serious and distractive pest of barley in the highland of Ethiopia. Its infestation often starts at the early seedling growth stage, and as damage progresses the aphid pressure increases and the infestation may even persist after heading and result in severe crop damage or total crop failure. This is mainly the case in the Belg season (February to May), which has low rainfall.

Russian wheat aphid can be controlled by different methods, but most farmers depend on synthetic chemicals, there is on enough published or unpolished information on cultural, biological and physical control methods of Russian wheat aphid on barley in Ethiopia. But cultural, biological and use of RWA-resistant cultivars are alternative means of pest control option, especially for self-subsistent Ethiopian farmers, which requires less investment and does not need special skill to implement, unlike synthetic chemical control. Genetic resistance is the main method for controlling obligate RWA and Integrated RWA Management. So, development of resistant barley cultivar, is best option to reduce yield loss by RWA.

Biocontrol agent of Russian wheat aphid is better control option to minimizing yield loss by RWA. Biological control remains essential and it is the cornerstone of economic and ecological friendly approaches to limit insect outbreaks. Identification and characterization of natural enemy of RWA are critical as is ensuring that which biological control agent suppress the RWA. After identification of natural enemy of RWA, following the principle of conservation of natural enemy, like avoidance of broad spectrum chemical which affect natural enemy of RWA. This entails understanding the ecological conditions that favor RWA variability across geographical areas.

Cultural control, which requires less investment from the farmers and does not need special skill to implement, is sustainable and easily available control option. Riedell (1990) suggested N fertilization as a useful strategy for limiting yield loss caused by RWA in plants that are deficient in nitrogen. So, integrating RWA resistant barley varieties and N fertilization could be considered as an effective RWA management strategy for resource poor farmers that reside in the highlands of Ethiopia.

Understanding of the dynamics of environmental conditions change both annually and on a long-term basis and incorporating cropping practices that will reduce the effects of stress, which influences susceptibility to some RWA. But basic study, like population dynamics, host range, regular monitoring is not get enough attention in Ethiopia. Biotypic status study is conducted but no variation between Ethiopian and USA biotype, the absence of genetic variation might be due to a recent spread of RWA from its area of origin. Study on population dynamics is the first step to design a sampling method. Therefore, the future research should focus on population dynamics, biotypes, biology, ecology and the economic thresholds and factors can cause fluctuations in aphid numbers. Study on factors such as weather, farming practice, plant age, emigration, disease, parasites, and predators to identify and maintain the one as control option.

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