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Relationship Between Desert Locust, *Schistocerca gregaria* (Forskål), Infestation, Environmental Factors and Control Measures in Gazan and Makkah Regions, Saudi Arabia

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Abstract: Desert Locust, *Schistocerca gregaria* (Forskål), is one of the most important insect pests in Saudi Arabia. Cultivated crops and the range lands are heavily affected by desert locust in some regions of Saudi Arabia. The objective of this study was to determine the extent of damage by the Desert Locust, *Schistocerca gregaria* (Forskål) to the range lands being used for grazing range animals in Gazan and Makkah regions of Saudi Arabia. However, it is very difficult to estimate accurately the total infested areas, which were sprayed with insecticides to control upsurges, outbreaks and plagues over the last five decades. Records of Desert Locust control are kept in the National Desert Locust Control and Research Center in Jeddah. Meteorological data was obtained from the Meteorology and Environmental Protection Administration (MEPA), Saudi Arabia. The data shows that the Desert Locust infestation was associated partially with the rainfall intensity in Gazan and Makkah regions. There was found a good relationship between Desert Locust infestation (Solitary phase), temperature and the relative humidity. The locust infestation was heavy during 1986-88, 1992-95 and 1997-98 and about 1.8 million ha were treated with insecticides. Out of the total breeding/infested area, 43% was treated in winter months (October-February) and the remaining 57% was treated in spring season (March-June). The infested area was sprayed with Marshall, Carbosulfan (20%), Malathion (96%, Clorpyrifos; (48%) Fipronil (12.5%), Sumithion (100%) and Decis (12.5%). The study showed an excellent potential to determine the active locust infestation period in relation to the environmental factors for its effective control with insecticide sprays to minimize crop damage. The study highlighted the needs for further investigations in other locust infested areas with different environmental factors for planning future desert locust control programs.

Key words: Desert locust, control measures, insecticides, gregarious, solitary, climatic conditions, migratory pests

INTRODUCTION

Desert Locust, *Schistocerca gregaria* (Forskål), belongs to the family Acrididae. It is well known to change its behavior and physiology in relation to the change in population density by forming swarms of adults or bands of wingless nymphs called hoppers. The locust swarms may contain billions of individuals behaving in unison and can migrate over thousands of kilometers. Desert locust is considered a serious threat to crop production in the Arabian peninsula due to their ability to form huge, mobile swarms in their Gregarious phase and because of their feeding habits on all varieties and parts of plants (Uvarov, 1931, 1977; Showler, 2002). The perception of this pest as a major threat to agricultural yields has led the governments of the affected countries to engage in emergency control operations involving chemical pesticides. Preventive control of localized Desert Locust outbreak, defined as a sudden increase in population exhibiting or beginning to exhibit Gregarious behaviour, is the corner stone of the current adopted strategy in containing the migrant Desert Locust pest (FAO, 1999).

The life span of Desert Locust is three to five months. It is extremely variable and depends on weather and ecological conditions (Ashall and Ellis, 1962; Roffey and Popov, 1968). Desert Locust has different stages called phases: (1) Solitarious phase, when the individuals have low population densities (2) The Gregarious phase, when they have high densities and (3). Transition phase, from Solitarious to the Gregarious stage and vice-versa known as transients. The behavioral change depends on the micro-scale environmental factors such as the spatial distribution of food plants and the macro-scale factors such as convergent wind fields that force Desert Locust to become concentrated in relatively small areas (Roessingh and Simpson, 1994). Temperature, rainfall and the wind influence the migration of both the

solitary adults and swarms (Rainey, 1963; Schaefer, 1976). During the last century, Desert Locust plagues occurred in the Middle East on seven different occasions i.e., 1901-1908, 1912-1917, 1926-1933, 1941-1947, 1949-1962, 1968 and 1987-1989 (Waloff, 1976). The longest and continuous plague in the Desert Locust area was believed to have started in the Empty Quarter of Saudi Arabia following the unusual high rainfall (Waloff, 1966; Lean, 1965). During 1949, it spread into the Arabian Peninsula and Iran as well as further east and west.

Early detection and consequently the efficient control of outbreak ensures not only overall success, but also reduces costs, scale and environmental hazards of chemical control. An accepted level of early detection can be achieved by routine monitoring of locust habitats and by forecasting where and how populations might develop (Showler, 2002). In addition, FAO has an important activity in controlling and preventing the Desert Locust upsurges, outbreaks and plagues by the created EMPRES (FAO, 2002). Before the late 1980s, longer residual insecticides such as dieldrin were applied as barrier in bands or blocks on vegetation (Steedman, 1988). Control campaigns against outbreaks and plagues were relied mainly on the sprays of conventional insecticides. Significant advances in tactics have been sparse (FAO, 2000), with the possible exception of fibronil, insect growth regulators and the biological control agents. Fipronil could be used for barrier or block application (Lockwood *et al*., 2000). Currently, FAO is actively engaged in coordinating the control strategy for early intervention to prevent the development of swarming populations by monitoring and adopting various control operations in the remote breeding habitats of the Desert Locust. Flexible strategies, to ensure an early effective detection and safer intervention that benefit from the emerging technologies, are needed such as using satellite images, GPS and the promising biological control, Myco-pesticides (Showler, 1997).

Saudi Arabia consists one of the most important locations of traditional breeding for Desert Locust (FAO, 1969; Karrar, 1974; Roffey, 1982; Steedman, 1990; Popov, 1997). Locust infestations occur very frequently in Saudi Arabia. Till to-date, no serious attempt had been made in Saudi Arabia that relates the locust infestations with the control measures and the environmental factors such as temperature, rainfall and relative humidity. The objective of this study was to conduct detailed analyses of historical data on Desert Locust infestation in Gazan and Makkah regions of Saudi Arabia, environmental factors and the control measures adopted to understand the role of each factor in regulating the Desert Locust population and its densities in the affected areas.

MATERIALS AND METHODS

The study was conducted at King Faisal University, Hofuf, Al-Hasa and the National Desert Locust Control and Research Center in Jeddah during 2005 and 2006. Field visits were organized to Gazan and Makkah regions to collect data from the respective Directorate General of Agriculture and offices of Meteorology and Environmental Protection Administration (MEPA, 2002) in Saudi Arabia. The study locations are shown in Fig. 1. The required data were collected from 1985-2002:

- Infestation (locations of Solitary hoppers, Solitary adults, Gregarious hopper bands or patches and swarms).
- Population density of Desert Locust before and after treatment at each location.
- Locations treated with insecticides.
- Type and formulations of insecticides used.
- Monthly meteorological data (temperature, humidity and rainfall) for Gazan and Makkah regions close to the Desert Locust breeding areas.

Chemical treatments: The following chemicals were applied for locust control as ULV application.

- Marshal (Carbosulfan, 20%): 2,3 dihydro-2,2-dimethyl-7-benzofuranyl ((dibutylamino) thio) methyl carbamate.
- Malathion 96% Diethyl (dimethoxythiophos-phorylthio) succinate.
- Clorpyrifos; 48% O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosphorothioate.
- Fipronil (12.5%) ((±)-5-amino-1-(2'6-dichloro-α, α, α-trifluoro-p-tolyl)-4-trifluromethylsulfinypyrazole-3-carbonitrile).
- Sumithion (100%) O,O-dimethyl O-4-nitro-m-tolyl-phosphorothioate (IUPAC).
- Decis (12.5%) (S)-a-cyano-3-phenoxybenzyl-(1R,3R)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylate.

Using Costat (1998) software program was utilized to establish the influence of various parameters on Desert Locust numbers and the level of infestation.

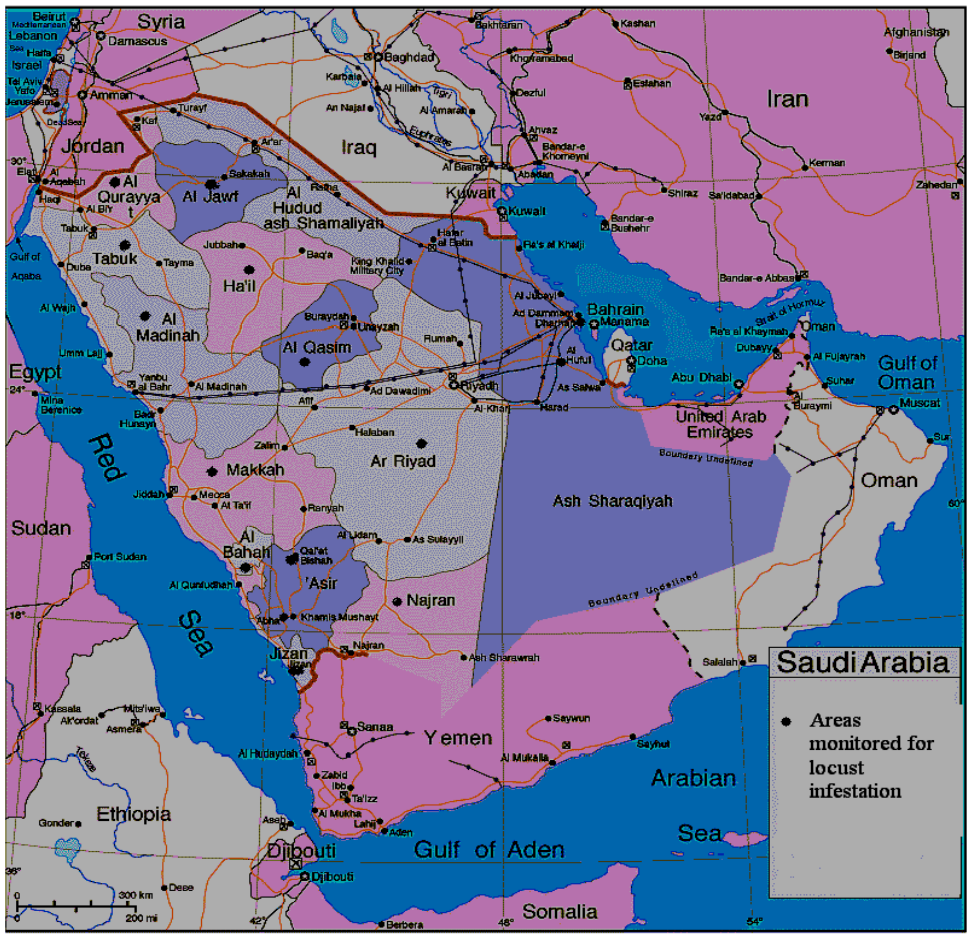

Fig. 1: Location map of study areas (Gazan and Makkah regions, Saudi Arabia) for monitoring Desert Locust infestation

RESULTS

Appearance of the Desert Locust in Gazan and Makkah regions of Saudi Arabia from 1985-2002 is shown in Table 1. In general the Desert Locust infestation in Gazan and Makkah was very high.

Seasonal activity of Desert Locust as Solitary hoppers, Solitary adults, Gregarious hopper bands or patches and swarms was monitored in Gazan and Makkah regions of Saudi Arabia from 1985-2002. Mean monthly meteorological data (temperature, humidity and rainfall) for Gazan and Makkah regions close to the locations of Desert Locust breeding was collected from the Meteorology and Environmental Protection Administration (MEPA, 2002), Saudi Arabia.

The data showed that the infestation of locust (Gregarious and Solitary phases) in Gazan region was reported in 1986, 1987, 1988, 1992, 1993, 1995 and 1998,

Table 1: Appearance of desert Locust in Gazan and Makkah regions, Saudi Arabia from 1985-2002

Year	Gazan	Makkah
1985	Sa	Gh, Sa
1986	Gh, Sa	Ga, Gh, Sh, Sa
1987	Ga, Sh, Sa	Ga, Gh, Sa
1988	Ga, Gh, Sa	Ga, Gh, Sa
1989	Sa	
1990		Sa
1991		Sa
1992	Ga, sa	Ga, Gh, Sh, Sa
1993	Ga, Gh, Sa	Ga, Gh, Sa
1994	Sh, Sa	Ga, Gh, Sa
1995	Ga, Sh, Sa	Sh, Sa
1996		Sh, Sa
1997	Sa	Sh, Sa
1998	Ga, Gh, Sa	Sh, Sa
1999	Sa	Sa
2000	Ga	
2001		Sa
2002		

Ga = Gregarious adults, Gh = Gregarious hoppers, Sa = Solitary adults, Sh = Solitary hoppers

throughout the study period (eighteen years of monitoring). Highest locust infestation (Gregarious phase) in Gazan region was reported in 1988 followed with 1998 whereas it was low in the other years. No infestation was reported from 1999-2002. The mean number of swarms was 6.7 and 1.7 in 1988 and 1998, respectively. The climatic parameters namely temperature, humidity and rainfall were 31.2°C, 67.5% and 12.6 mm in 1988 while it was 30.8°C, 67.8% and 407.4 mm 1998, respectively. Solitary infestation in Gazan region was reported in most of the study period except 1990, 1991, 1996, 2000 and 2002. The highest infestation of Solitary was reported in 1993 and 1997 (Fig. 2-7).

Data revealed that the infestation of Gregarious phase in Makkah region was reported in 1985, 1986, 1987, 1988, 1992, 1993 and 1994, throughout the study period (total of 18 years of monitoring). Locust Solitary phase infestation in Makkah region was reported in most of the study period except 1989 and 2000. The highest infestation of Solitary phase in Makkah region was reported in 1993, 1995 and 1997, while the mean of climatic conditions for those years were 30.9°C, 44.7% and 7.5 mm, 31.1°C, 45.6% and 200.4 mm, 30.8°C, 47.5% and 204.6 mm, respectively (Fig. 8-13).

The data revealed that the locust infestation was considerably heavy during 1986-88, 1992-95 and 1997-98

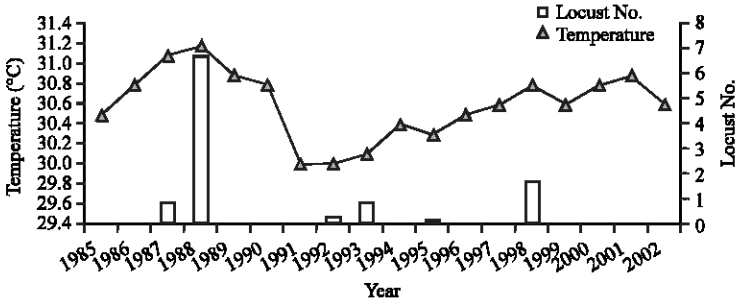

Fig. 2: Seasonal activity of Desert Locust (Gregarious swarm) No. in Gazan region from 1985-2002 and its relation with temperature

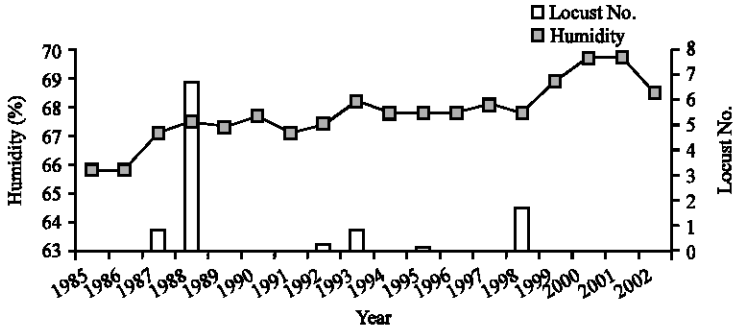

Fig. 3: Seasonal activity of Desert Locust (Gregarious swarm) No. in Gazan region from 1985-2002 and its relation with humanity

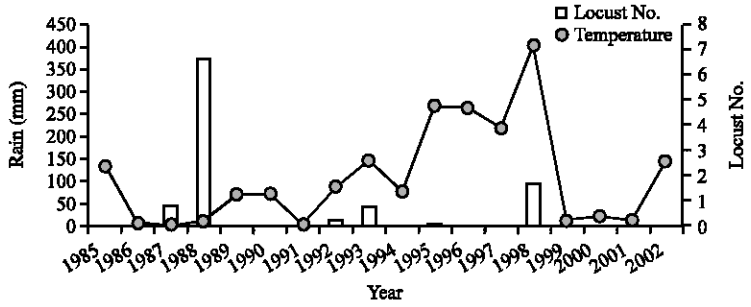

Fig. 4: Seasonal activity of Desert Locust (Gregarious swarm) No. in Gazan region from 1985-2002 and its relation with rate of rain

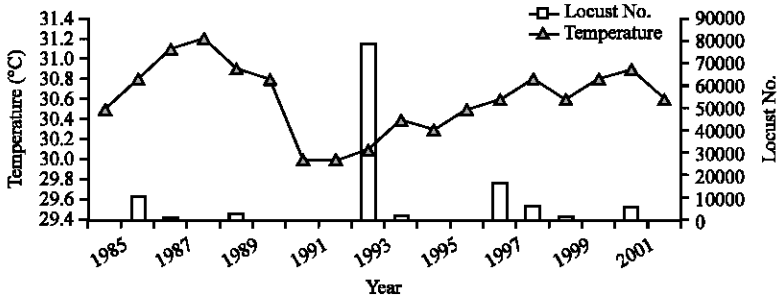

Fig. 5: Seasonal activity of Desert Locust (Solitary) No. in Gazan region from 1985-2002 and its relation with temperature

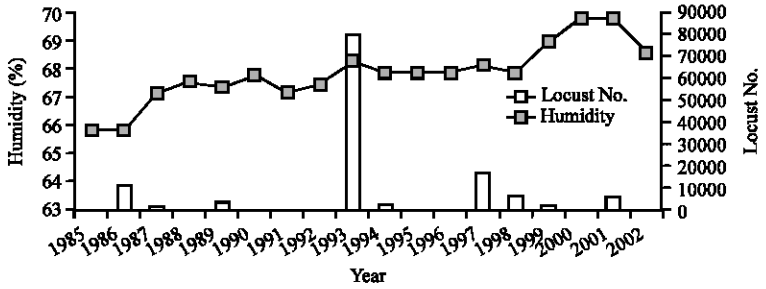

Fig. 6: Seasonal activity of Desert Locust (Solitary) No. in Gazan region from 1985-2002 and its relation with humidity

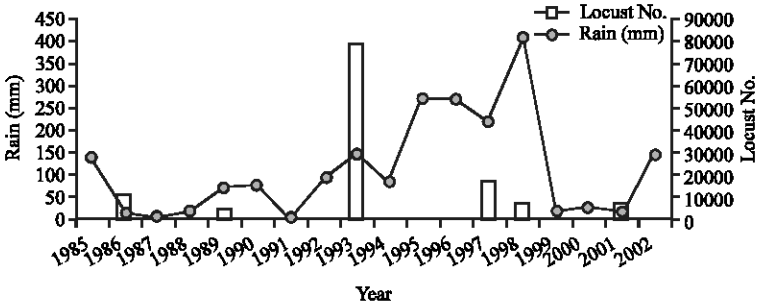

Fig. 7: Seasonal activity of Desert Locust (Solitary) No. in Gazan region from 1985-2002 and its relation with rate of rain

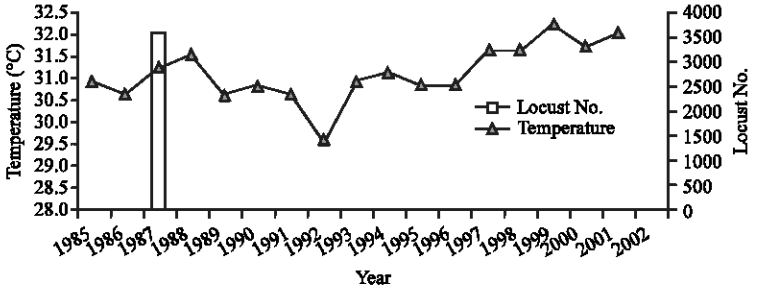

Fig. 8: Seasonal activity of Desert Locust (Gregarious swarm) No. in Makkah region from 1985-2002 and its relation with temperate

that warranted effective control operations. During those periods, more than 1.8 million ha of infested area was treated with insecticides. Approximately 43% of the breeding areas were sprayed in the winter months (October-February) and the remaining 57% were sprayed in the spring season (March-June).

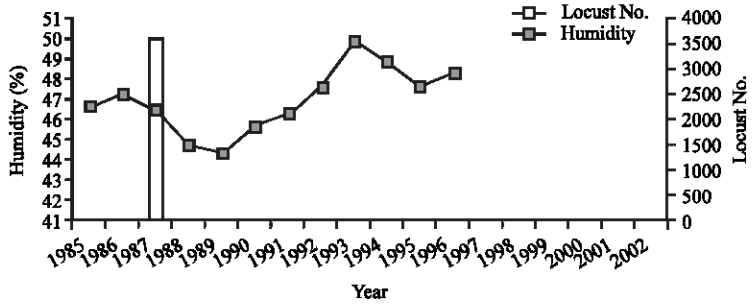

Fig. 9: Seasonal activity of Desert Locust (Gregarious swarm) No. in Makkah region from 1985-2002 and its relation with humidity

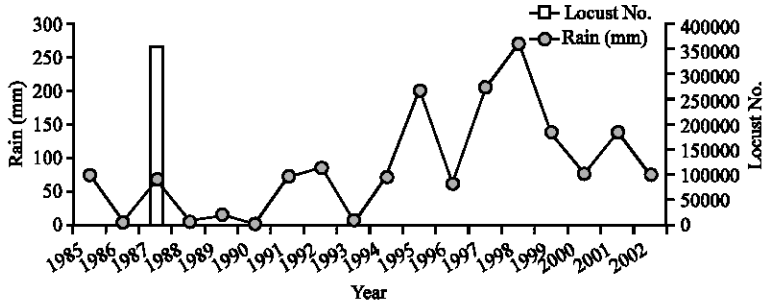

Fig. 10: Seasonal activity of Desert Locust (Gregarious swarm) No. in Makkah region from 1985-2002 and its relation with rate of rain

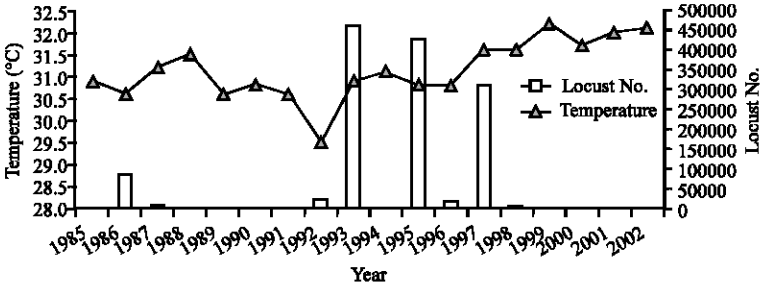

Fig. 11: Seasonal activity of Desert Locust (Solitary) No. in Makkah region from 1985-2002 and its relation with rate of temperature

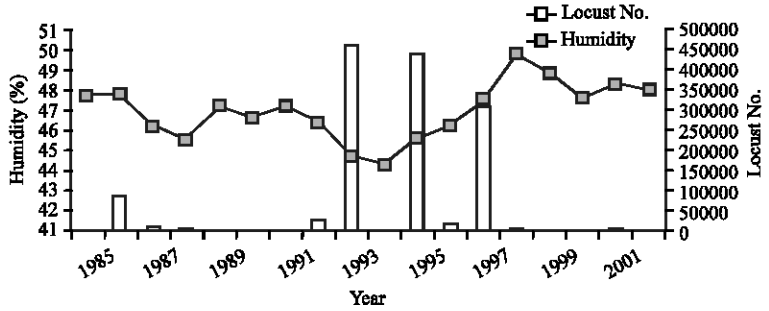

Fig. 12: Seasonal activity of Desert Locust (Solitary) No. in Makkah region from 1985-2002 and its relation with rate of humidity

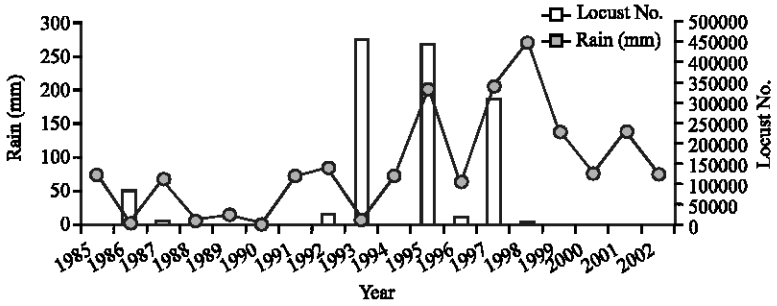

Fig. 13: Seasonal activity of Desert Locust (Solitary) No. in Makkah region from 1985-2002 and its relation with rate of rain

DISCUSSION

Desert locust upsurges and infestation depend mainly on the soil type, nature of vegetation and the climatic conditions. The research findings show that the Desert Locust infestation in the study area (Gazan and Makkah regions) was partially associated with the rainfall intensity. A good relationship was found between Desert Locust infestation (Solitary phase), temperature and the relative humidity which relates to the study objectives for determining relationship between the Desert locust upsurges and the environmental conditions. The locust infestation was heavy during 1986-88, 1992-95 and 1997-98 that warranted control operations and about 1.8 million ha were treated with insecticides. Similar conclusions were drawn by Roessingh and Simpson (1994) who stated that the behavioral change depends on the micro-scale environmental factors such as the spatial distribution of food plants and the macro-scale factors such as convergent wind fields that force Desert Locust to become concentrated in relatively small areas. Some researchers noted temperature, rainfall and the wind influence on the migration of both the Solitary adults and swarms (Rainey, 1963; Schaefer, 1976). The study showed a great potential to determine the active locust infestation period in relation to the environmental factors such as temperature, rainfall and relative humidity for its effective control with insecticide sprays to minimize crop damage in a certain period of the year. The results further emphasized the needs to carry out more studies to cover other potential areas of the Kingdom which are likely to be affected by desert locust infestation in order to develop a comprehensive and cost effective desert locust control program for minimizing the natural vegetation, cultivated crops and rangeland losses.

In old days, the control of Desert Locust depended on physical collection of the insects, preferably in their younger stages. In 1972, the Emergency Center for Locust Operations was set up to coordinate with donor capitals on pledges and commitments. Because of the huge environmental implication of outbreaks of Desert Locust, the US Agency for International Development has been and continues to be involved in the problems of Desert Locust and grasshopper control in Africa, the Arabian Peninsula and South Asia (AID, 1987).

Pest management intervention threshold is mostly developed for sedentary or seasonal pests that occur in cultivated fields or orchards. This differs markedly from the Desert Locust which in highly mobile, attacks a wide range of crops with different economic values and breeds in non-cropped areas. Further, phase transformation in the Desert Locust can be accelerated or reversed by unpredictable environmental changes. However, majority of the Desert Locust affected countries prefer to intervene at the Gregarious phase to avoid any possibility of expansion. Therefore, such countries should be involved extensively in the operations of EMPRES, which has created an early warning system for Desert Locust to prevent it from developing into serious outbreaks, upsurges and plagues.

Despite overall success of control measures, there is a continuous need to improve the existing application methods and associated safety measures to minimize potential adverse environmental and human safety risks. However, it is necessary to detect Desert Locust population as early as possible before its expansion into plagues. Therefore, the survey teams should be trained on regular basis on the use of satellite images to direct their surveys towards highly potential areas of Desert Locust to predict breeding and migration and to develop the control strategies. In addition to that, the survey teams should also be trained regularly on the use of GPS to locate the exact locust infested area for spraying insecticides to develop cost effective control operations.

The study showed an excellent potential for the development and implementation of latest promising biological control measures.

It is, therefore, imperative to devote more attention to the Desert Locust infestation which, with its facility to survive and breed in semi-desert areas in the remote and difficult terrain, still constitutes the insect threat to agriculture in Africa and the Middle East. Furthermore, this species, more than any other, is likely to be the future insect pest that needs constant and continuous vigilance in each affected country to avoid its expansion to the non affected countries.

CONCLUSIONS

The study showed that the Desert Locust infestation is associated partially with the rainfall intensity in Gazan and Makkah regions. There was found to be good relationship between Desert Locust infestation (Solitary phase), temperature and the relative humidity. The locust infestation was heavy during 1986-1988, 1992-1995 and 1997-1998 that warranted control operations and about 1.8 million ha were treated with insecticides. Out of the total breeding/infested area, 43% was treated in winter months (October-February) and the remaining 57% was treated in spring season (March-June). The study showed an excellent potential to determine the active locust infestation period in relation to the environmental factors for its effective control with insecticide sprays to minimize crop damage. Further studies are required to cover other potential areas of the Kingdom which are likely to be affected by desert locust infestation in order to develop a comprehensive and cost effective desert locust control program for minimizing crop and rangeland losses.

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