International Journal For Technological Research In Engineering
Volume 8, Issue 2, October-2020 *ISSN (Online): 2347 - 4718*

LOCUST CONTROL MANAGEMENT: A TIME TO CHANGE FROM TRADITIONAL TO TECHNOLOGY – AN EMPIRICAL ANALYSIS

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ABSTRACT: The locust has caused great losses to agriculture in India.Highly mobile swarms threatened a large territory of vegetation in Rajasthan, Punjab, Gujarat, Madhya Pradesh and Tamilnadu. The locust migrates on downwind where winter, spring and summer rain falls for breeding. In India, it is accounted as ten plagues during 1863 - 1962 and 18 upsurges from 1963 to 2012. This paper reported the efficacy analysis of newer technology over the traditional method on locust control management. The newer technology includes hybrid drones for spraying pesticides, GPS for localization, GIS tools with computers have been imparted for quick data management and analysis for planning locust control.The impact of newer technologies for locust control management in India for past decades has been successful. This study provides insights into the usage of drones for locust control on different types of vegetation and enhances the yield of the invasion area and also helps to protect the crops of small farmers as well as grazing grounds for the livestock.
KEYWORDS: Locust control, Traditional method, Locust control in India, UAV,Hybrid drones

I. INTRODUCTION

Devastating locust invasions have been accepted as a national threat to agriculture and livestock for many years. The infestations of locusts which ravages vast agricultural land under a variety of crops, which affects wild plants, grazing lands, forests and crops at different stages vary greatly from year to year and from country to country resulting in heavy crop losses and also disturbing a eco-chain reaction with adverse effects such as famine, economic down, relinquish of cultivation, diversion of labour, high cost for control measures and so on. Globally, approximately 64 countries representing 20% of land surface (approximately 30 million square kilometers) got affected by the desert locust during plague period. During recession time, locust population grows at low densities of invasion is confined to 16 million square kilometers arid areas in 30 countries of North Africa, Middle East and Northwest India. These countries were affected by invasions of desert locust swarms, which attacked almost all varieties of crops and vegetation often resulting in famines and immense economic losses. Locust invasions are dramatic, sudden, cover large areas in a short period and almost all green in their path is destroyed. It is the destructive potential which is dreaded as locusts come so suddenly in such large numbers and swarm across international boundaries and due to this reason locust invasion attract so much public attention and cause international concern. Locusts are invertebrate animals with highly migratory habits, marked polymorphism and voracious feeding behavior. They are able to take rapid advantage of the climate and geography can survive in temperature range from 0 degree to 60 degree and can speed up or slow down their life cycle. Locusts have been feared and revered throughout history. Related to grasshoppers, these insects form enormous swarms that spread across regions, devouring crops and leaving serious agricultural damage in their wake. Plagues of locusts have devastated societies since the Pharaohs led ancient Egypt, and they still wreak havoc today. Locusts look like ordinary grasshoppers—most notably, they both have big hind legs that help them hop or jump. They sometimes share the solitary lifestyle of a grasshopper, too. However, locust behavior can be something else entirely.

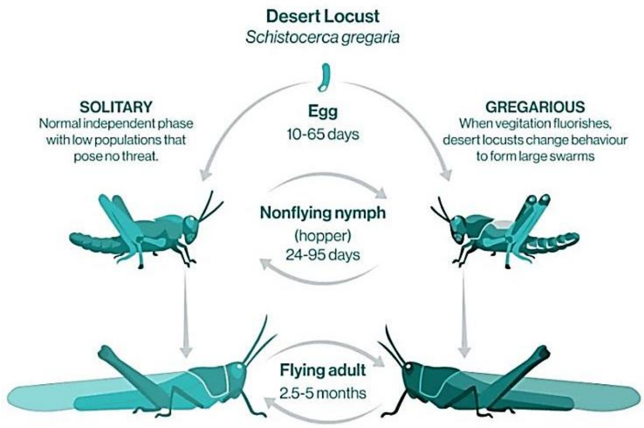

Fig. 1 Life Cycle of locusts

During dry spells, solitary locusts are forced together in the patchy areas of land with remaining vegetation. This sudden crowding releases serotonin in their central nervous systems that makes locusts more sociable and promotes rapid movements and more varied appetite. When rains return—producing moist soil and abundant green plants—those environmental conditions create a perfect storm: Locusts begin to produce rapidly and become even more crowded together. In these circumstances, they shift completely from their solitary lifestyle to a group lifestyle in what's called the gregarious phase. Locusts can even change color and body shape when they move into this phase. Their endurance increases and even their brains get larger locusts can become gregarious at any point in their lifecycle. On hatching, a locust emerges wingless as a nonflying nymph, which can be either solitary or gregarious. A nymph can also change between behavior phases before becoming a flying adult after 24 to 95 days.

II. LOCUST CONTROL STRATEGY

The primary objective of strategies designed for locust control is to control the size of the total population of locusts and not only to attack locusts in or around vegetation. This is an accepted way to prevent crop loss with such mobile pests, and to prevent threats.

Red and Migratory Locusts. These species have outbreak areas where the first sequences of a plague develop. The aim of control is to prevent the plagues by controlling any bands and swarms which form in these areas. Swarms of the African Migratory Locust have formed outside the recognized outbreak areas and caused local upsurges on a significant scale, notably in the Republic of South Africa during 1982 and in Sudan during 1985, but these have not led to a plague. Similarly swarms have escaped from the Red Locust outbreak areas many times but no plagues have resulted.

Tree Locust. This species does not migrate long distances and is, therefore, a localized problem.

Desert Locust. Upsurges leading to plagues are believed to occur through sequences of successful breeding by initially solitary-behaving populations. The sequences start in the arid central belt recession area. Each upsurge then requires a series of above average rains in areas to which the locust migrate in successive generations. Some experts claim that control of gregariously behaving locust populations at the start of the upsurge sequences can prevent a plague. However, while the gregarious populations are obvious targets for spraying, their destruction does not necessarily make significant inroads into the critical mass of the population. Solitary locusts, which are not targets in practical or economic terms, migrate and continue to multiply. These locusts expand into an ever increasing area for several generations and it is only when they come together into swarms and become recognizable targets that effective control can be achieved.At present, for locust attacks, the application of wide ranged insecticides, often on a large scale, is the only effective control measure, and so far resistance to these chemicals has not developed. In order to kill locusts with insecticide they must either swallow it or get it on the outside of their bodies. This is achieved by either stomach action or contact action. Stomach action is the process of adding the insecticide on or in the food, either natural vegetation or specially prepared bait. Contact action is achieved by spraying the insecticide directly on to the locusts in such a form, often dissolved in oil, that it will penetrate the cuticle.The insecticide is actually applied or offered to the locusts in one of three forms: bait, dust or spray. All forms are used for killing by stomach action, and dusts and sprays are also used for killing by contact action.

2.1 Baiting

Bait is usually formulated by the anti-locust organizations themselves. The insecticide, or insecticide and a biological control agent, is mixed with a material, the carrier, which locusts eat readily. The insecticide chosen for mixing with the carrier must be one which has a high stomach toxicity to locusts and is available in a convenient form. Carbamates such as bendiocarb and propoxur are now commonly used as baits. Tests have shown that the following products are the best carriers for locust bait: maize meal, wheat bran, maize bran, cotton seed husk and rice bran. Others which can be used but are not as good are: sugarcane waste, millet stalk, groundnut husk, corn cob, sawdust and rice husk. The carrier chosen will depend on what is available and also on the price; but it must be remembered that the material which is cheapest at source may not turn out cheapest in the long run if the locusts do not relish it. A large part of the cost of baiting is the cost of transporting the bait to the locusts, so that it is not worthwhile paying the transport costs unless the material gives good results when it reaches them. The effectiveness of the bait will clearly depend upon the concentration of the insecticide it contains. The concentration is usually 1 or 2% active ingredient.

2.2 Dusting

Commercial preparations of insecticidal dusts consist of an insecticide mixed with some inert material like powdered chalk or talc. The most suitable insecticidal dust for killing locusts and grasshoppers is bendiocarb. Dust can be applied by a variety of methods.

- By hand. When dust is distributed by hand it is advisable to use a dusting bag or to mix the commercial product with fine sand to give a better distribution. One handful of insecticide dust to four handfuls of dry sand or silt.
- By hand-blower (Fig. 139). These block easily. Use the dust as supplied commercially.
- By machine powder-duster. Care must be taken not to apply the dust in swaths more than about 10 m wide, otherwise the dust will be to diffuse to achieve an adequate kill.

Experience has shown that the best results are obtained when dusting is carried out under moist conditions, that is, high relative humidity or with dew on the vegetation. It is unpleasant to use by hand, and there are tiresome and time-wasting difficulties due to blockages in dusting machines and also there is a safety risk due to inhalation of the small particles.

2.3 Spraying

In this method of locust control, liquid insecticide is broken up into fine drops and sprayed either on to the locusts or on to the vegetation which they eat. Spraying can be done either from the ground or from aircraft. Spraying can be successfully carried out with many types of machine. Suspensions, emulsions or oil solutions of insecticides may be used. To obtain the best kills at the minimum cost, however, the insecticides require special formulations and an appropriate spraying machine should be chosen. Until about 30 years ago all liquid insecticides were applied in large volumes diluted with water. For locust control this caused problems because water often had to be transported large distances. It was realized that much greater areas could be treated more quickly and cheaply, if the insecticide was applied at high concentration in a specially prepared, effectively non-volatile formulation. This is the basis of ultra-low volume (ULV) spraying. It is clear, however, that such concentrated material must be spread over a large area and must collect on the locust and on vegetation and not simply allowed to 'rain down'. This means using very small drops which are spread by the wind. Although easy in theory, in practice, spray application is more complicated and variable, and the ideal technique for every situation is as yet largely undetermined. Nevertheless, the advice that is given here will give good results. ULV spraying can be used in one or more ways simultaneously depending on locust life-stage (hoppers or swarms), terrain and resources. Techniques include:

Band spraying of individual hopper bands by ground or air – pesticide efficient but it is very difficult to locate and delineate the bands.

Block spraying when surface area is highly infested (say 5%) with hopper bands - rapid, less pesticide-efficient, and more environmental risky due to the large areas covered.

Barrier spraying of vegetation strips using persistent chemicals (originally dieldrin) in order to be effective when hoppers arrive and during successive waves of hatching.

Settled swarm spraying by ground or air must take place in the relatively short window between dawn and departure of the swarm (requiring swarm location the previous night).

Flying swarm spraying has been practiced successfully in the past, but most Desert Locusts pray aircraft are not specially equipped to prevent entry of locusts into the air intakes and do not have adequate screen-washing to cope with inevitable accidental encounters with the locusts. It is potentially the most rapid and pesticide-efficient spray strategy (Symmons, 1993), but most pilots will not attempt it because of the dangers.

III. HYBRID DRONES FOR LOCUST CONTROL

The Indian government stated that it has stepped up aerial spraying capacity of pesticides by deploying Bell helicopter as well as Indian Air Force (IAF) deployed Mi-17 choppers besides drones to fight crop-threatening desert locusts. This follows the UN body Food and Agriculture Organisation's (FAO) updated warning India to be on high alert during the next four weeks as locusts continue to breed. On continuing, swarms of immature pink locusts and adult yellow locusts were active in Barmer, Bikaner, Jodhpur, Nagaur, Ajmer, Sikar and Jaipur districts of Rajasthan, Jhansi district of Uttar Pradesh and in Tikamgarh districts of Madhya Pradesh, the government said in a statement. The ministry announced 15 drones are deployed at Barmer, Jaisalmer, Bikaner, Nagaur and Phalodi in Rajasthan for effective control of locusts on tall trees and in inaccessible areas through spraying of pesticides. India is the first country that is using drones for locust control. Presently, 60 control teams with spray vehicles are deployed in Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh, and more than 200 central government personnel are engaged in locust control operations. The country is battling the worst locust attack in 26 years and using the latest technology and equipment to stop its spread.So far, control operations have been done in 1,43,422 hectares in Rajasthan, Madhya Pradesh, Punjab, Gujarat, Uttar Pradesh and Haryana by the Locust Circle Offices (LCOs).The state governments have also undertaken control operations in 1,32,465 hectares area in Rajasthan, Madhya Pradesh, Punjab, Gujarat, Uttar Pradesh, Maharashtra, Chhattisgarh, Haryana and Bihar.In the intervening of July, the control operations were carried out at 22 places in 7 districts of Rajasthan and one place each in Jhansi district of Uttar Pradesh and Tikamgarh districts of Madhya Pradesh by LCOs.

Garuda Aerospace Pvt Ltd (GAPL) along with various agencies deployed drones to control locust in the area of Rajasthan, Gujarat, Punjab, Haryana, Madhya Pradesh and Uttar Pradesh.

Item	Unit	Parameter	Remarks
Model Number	-	T416HD-A	Quadcopter
Net weight	kg	22	Exclude Battery ,Gasoline, Liquid
Take off weight	kg	43	Fixed load ≤38
Battery	kg	2.5	2P6S 10000mah
Propeller	inch	40	4013 straight carbon fiber
Fold size	mm	1320 x 700 x 600	L x W x H
Fold Size	mm	780 x 700 x 600	L x W x H (without propeller)
Unfold Size	mm	2316x2266 x 600	L x W x H
Nozzle	-	4	Fan nozzle head
Hybrid Model	-	F6000	5.0 kW constant power / 6.0 kW max
Gasoline	-	95# or above	
Fuel	-	6l/hr	When hovering
Hybrid Voltage	-	125	48V
Wind Resistance	-	3 - 4	
Max. Flight Speed	m/s	≤ 10	
Control Range	m	≤2000	

Table 1 : Technical Specification of Hybrid Drone

Aerial sprayers produce drops in a range of sizes called the drop spectrum. Drops are measured by diameter in millionths of a metre (μm). Two terms often used in connection with spraying are: volume median diameter (VMD) is the drop diameter where half the total spray volume is in smaller drops and half is in larger ones. Number median diameter (NMD) is the drop diameter where half the total number of spray drops is smaller and half are larger. The volume of a drop is given by $d^3/6$ where d is the diameter of the drop. If you halve the diameter you get eight small drops for every large one. For example, one 200 µm drop will make eight drops of 100 µm, 64 drops of 50 µm and 1000 drops of 20 µm diameter. This means the NMD is always less than the VMD. The VMD/NMD ratio is a measure of the dispersion of the drop spectrum. This ratio does not have a consistent meaning in terms of the drop spectrum, although a small ratio indicates a narrower drop spectrum than a large ratio. There is no single parameter which represents the drop spectrum completely. The best way to describe the spectrum is to give the proportion of the total volume of insecticide emitted within the drop size range which accounts for most of the emitted insecticide. For example, of the total volume of spray emitted by a Micronair AU5000 on drone, 80% is in a drop size between 5 and 120 µm. Whereas, of the total number of drops, 80% are between 5 and 56 µm. That is, a relatively small number of large drops account for a substantial percentage of the total volume of spray. Our drones flew over

1. 17 districts of Uttar Pradesh (Agra, Aligarh, Mathura, Bulandshahr, Hathras, Etah, Firozabad, Mainpuri, Etawah, Farrukhabad, Auraiya, Jalaun, Kanpur, Jhansi, Mahoba, Hamirpur and Lalitpur)
2. 8 districts in Rajasthan (Barmer, Jodhpur, Nagaur, Bikaner, Ganganagar, Hanumangarh, Sikar and Jaipur),
3. 7 districts in Madhya Pradesh (Satna, Gwalior, Seedhi, Rajgarh, Baitul, Devas, Agar Malwa)
4. 4 districts in Haryana (Sirsa, Bhiwani, CharkhiDadri and Rewari)
5. 3 districts in Gujarat (Banaskantha, Patan and Kutch)

Fig. 2. Locust killer drones

IV. RESULTS AND DISCUSSIONS

The Ministry of Agriculture had said control operations have been stepped up and drones will be deployed for aerial spraying of insecticides in the affected states. Locust containment measures and sprinkling operations have been conducted in 303 locations spread over more than 47,000 hectares till Wednesday in 21 districts of Rajasthan, 18 in Madhya Pradesh, two in Gujarat and one in Punjab, it added.

Method of control	Weight of ULV insecticide or Bait (tonnes)	Drones/spray team vehicles/delivery vehicles	% infestation resources could treat
Farmer control with bait	9000	1000 vehicles	25
Farmer control with ULV spray	75	2 vehicles	25
Plant Protection department team with bait	12000	1500 vehicles	100
Plant Protection department team with ULV spray treatment of individual hopper bands	50	500 vehicles	100
Plant Protection department team with ULV ground block hopper band spraying	1500	1800 vehicles	100
Aerial ULV block hopper band spraying	1500	250 drones	100
Aerial ULV swarm roost site spraying	60	12 drones	100
Aerial ULV spraying of flying swarm	40	8 drones	100

Table 2 :Comparison between traditional and drone

V. CONCLUSION

Now a day's newer technologies are adopted by the Indian government to control the locust invasion over the vegetation. In India, it is clearly proved that the drone based aerial spraying controls the locust effectively. In this paper, we presented how far drones are effectively deployed in the locust control management process. Here we compared the traditional method and drone based aerial spraying in terms of volume of insecticides, area of control, time and safety. Whatever it may be it is established in India that preventive control method encompassing early intervention for desert locust bands and swarms control is best suited to maximize agricultural production ,is economically viable and environment friendly due to less use of the pesticides. Thus we see that the early prevention strategy has achieved its original objective of preventing damage to major agricultural zones in invasion area. This strategy has also reduced the size of upsurges and time for control thus helping to protect the crops of the small farmers on one hand and the grazing grounds for the livestock on the other.

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