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Biodiversity of natural enemies in grape ecosystem in three different locations of Vijayapur District of Karnataka

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Abstract
We undertook comparative analysis of natural enemies in grape ecosystem in Vijayapur District of Karnataka during *rabi* season of 2016-17(October-April). Studies included three locations namely Vijayapur (Study area-1), Aliyabad (Study area-2) and Tikota (Study area-3) where in common agronomic practices were maintained but different plant protection measures for major insect pests. Natural enemies were collected through different methods *Viz.*, Herbivore induced plant volatile (HIPV), Yellow sticky trap (YST) and Sweep net (SN). A total of 563.33, 1035.55 and 1466.80 natural enemies were collected from study area-1, 2 and 3 respectively. Relative abundance of natural enemies at three locations was also calculated, the highest abundance was recorded for coccinellids and lowest abundance for ichneumonids. The Simpson index values were 0.76, 0.79 and 0.81, Shannon index 1.68, 1.70 and 1.73 and Evenness were 0.96, 0.93 and 0.87 for study area-1, 2 and 3 respectively. Our results showed that higher diversity was found in Tikota.

Keywords: Biodiversity, grape, natural enemies, HIPV, YST, SN, Relative abundance

1. Introduction
Grape (*Vitis vinifera* L.) is one of the most important fruit crops of temperate zone which has acclimatized to tropical and sub tropical agro climatic conditions prevailing in the Indian sub-continent. Originated in Western Asia and Europe, it is fairly a good source of minerals like calcium, phosphorous, iron and vitamins like B1 and B2. It was introduced to India by the Persian invaders in 1300 A.D. It is extensively grown in France, Italy, America, Africa, Australia, Algeria and India. India is the 13th largest producer consisting 2.00 per cent of the global production.
In India, grapes are cultivated in an area of 118.74 thousand ha with a total production 2,585.35 thousand MT and productivity of 21.77 tons/ha. The major grape growing states in India are Maharashtra 75.79 per cent, Karnataka 17.23 per cent, Tamil Nadu 2.39 per cent, Telangana 1.04 per cent, Mizoram 2.06 per cent, Andhra Pradesh 0.36 per cent and Punjab 0.35 per cent and amounting to nearly 90 per cent of the total production.
Karnataka is the second largest grape growing state in India after Maharashtra, with an area of 20.46 thousand ha with a production of 302.39 thousand MT and productivity of 14.78 tons/ha. Grape growing regions are located in the North and South interior Karnataka and South interior Karnataka. North interior Karnataka comprises Vijayapur, Bagalkote, Belagavi, Koppal, Bidar and Gulbarga. In 2015-16, Vijayapur district contributing an area of 10562 ha, production of 211640 tons, with average productivity 20 t/ha. Large acreages of grape cultivation is quite evident in Basavana Bagewadi, Vijayapur, Indi, Muddebihal and Sindgi taluks of Vijayapur [1].
Major proportion of production is hampered by pests and diseases. Important diseases are downy mildew, powdery mildew, anthracnose, bacterial canker, rust, leaf blight and bunch necrosis, dead arm and wilt.
Commercial cultivation of grapes tend to attract various kinds of pests to the vineyards. In India as many as 60 species of insects and a few mites have been found damaging vines (Wadhi and Batra, 1964) [17]. Balikai and Kotikal (2003) recorded as many as 26 pests infesting grapevines in Northern Karnataka [2]. Mani *et al*. (2014) reported that overall 653 pests are known to damage the crop in different grape growing regions of the world. In India 100 pests are known to damage the crop in which 15-20 are very important [12].

The pests can be best managed using chemical insecticides. But the adverse effects of insecticides have made the scientists to search for alternatives to chemical control based on health, environmental and economic concerns and such alternative is Biological control which involves predators, pathogens and parasitoids. Though grape is one such high pesticide consuming crop, however depending upon the area, the natural enemies' complex will vary (Solomon and Schettler 2000) [16].

The biodiversity in any ecosystem is affected by biotic and abiotic factors. Biotic factors are food, nourishment, homotypal and heterotypal effects. Abiotic factors are temperature, light, humidity, medium (soil and air). Agricultural intensification, while yielding more crops, generally has detrimental impacts on biodiversity. However, intensified agricultural systems often have fewer pests than more ''environmentally-friendly'' systems, which is believed to be primarily due to extensive pesticide use on intensive farms. In turn, to be competitive, less-intensive agricultural systems must rely on biological control of pests (Schowalter 2006) [15].

Thus Conservation Biological Control (CBC) is a strategy that enhances guilds or communities of both specialist and generalist natural enemies is now viewed as a pest management strategy, very likely to improve crop protection. Another factor that has encouraged and enhanced the use of CBC in many crop systems is the availability and use of pesticides that are narrow-spectrum and safe to many beneficial insects and mites (James *et al*., 2004) [8]. However many of the recommended insecticides are highly toxic to predators and parasitoids (Khan *et al*., 2015) [11]. The information pertaining to the biodiversity of predators and parasitoid complex occurring in Grape ecosystem is meager and their spatial distribution and species richness and diversity *etc* are unexplored. Hence, it is necessary to know about natural enemies diversity and richness.

2. Materials and Methods

This study was carried out in the grape orchards of Vijayapur District of Karnataka state situated in Northern dry zone (Zone-3) between16^{0}2, latitude and 76^0 42, longitude with an altitude of 593.8 meters above the mean sea level. The total geographical area of the zone is 47.84 lakh ha out of which 36.63 lakh ha area is under cultivation. The most important characteristic feature of this zone is the lowest rain fall (Avg. 602mm) occurring in about 30-35 rainy days. Both black and red soils are predominant in this zone with varying depths to large extent. The rainfall is bi-modal in nature with the highest peak in July. Maximum temperature of more than 30°C prevails throughout the year except during the January. The relative humidity is uniformly higher during rainy months from June to December and uniformly lower during pre-summer and summer months from January-May.

The natural enemies were collected by the following different methods to know the present status of natural complex on major pests of grapes during *rabi* season of 2016-17(October-April) on grape. Three fields were taken for experimentation (Vijayapur, Tikota and Aliyabad). Agronomic practices were common in these the fields as per the package of practices, but plant protection measures differed between the locations w.r.t doses of pesticides and also number of applications and timing of application. This is the main criteria considered for studying the biodiversity of natural enemies.

In the present study, collection methods *Viz.*, Herbivore induced plant volatile, yellow sticky trapping and net sweeping were adopted to collect the natural enemies at regular weekly interval between October –April (2016-17).

2.1 Herbivore Induced Plant Volatile

The selected vine yards were divided in to five blocks of an area of 0.25 acre per each block with one hundred and fifty vines. An isolation distance of 50 m was maintained between each block. HIPV (Herbivore induced plant volatile) Methyl salicylate 99-100% (Lobal chemie) was delivered through saturated cotton wicks @ 4 wicks/block which was placed in small perforated plastic container. Four yellow sticky traps (YST) were maintained in each block of an area of 0.25 acre to trap the natural enemies adjacent to Herbivore induced plant volatile dispenser. Observations on natural enemies were made weekly interval and yellow sticky traps were replaced once in a week. HIPV was changed at 15 days interval during the entire study period (October –April 2016-17).

2.2 Yellow sticky trap

The traps used in the study were constructed from yellow sticky card uniformly coated with a thin layer of an adhesive compound mixture of synthetic hydro carbon polymers on both side. Observations on natural enemies was made weekly interval and yellow sticky traps were replaced once in a week. Four traps were used for each block of an area of 0.25 acre. Totally five blocks were used for the study. An isolation distance of 50m was maintained between each block. The collections were made between October- April 2016-17.

2.3 Net sweeping

Five orchards of 0.25 acre were selected for the study. Collections were made from triangular net, by sweeping minimum 15 times at each spot; sweeping was done on diagonal basis at regular interval. The sweep net designed and described by Noyes (1982) was used for collection.

The handle (aluminium) was about 1.0 m long with triangular head. The net bag made up of strong and durable white terylene with a very fine mesh that retain even the minute predators and parasitoid inside the net but allowing easy passage of air was used. After each sweep the insects were transferred into polythene bag and brought to lab and cotton dipped in the chloroform was put into the predators and parasitoids collected polythene bags for 10-15 minutes. The predators and parasitoids were stored and separated by using an aspirator and stored using suitable storage methods.

2.4 Preservation of natural enemies

Two categories of permanent preservations *viz.*, liquid preservation and dry preservation as described by Noyes (1982) were followed.

2.5 Documentation of input usage pattern in grape ecosystem

Information on input usage pattern in grape crop in three study areas (Vijayapur, Aliyabad and Tikota) was generated through the questionnaires by personal interview with grape farmers from Appendix- I, II, III and IV respectively.

2.6 Statistical analysis

The field data averaged into respective parameter requisites was subjected to suitable transformation. After proper analysis, data was accommodated in the tables as per the need of the objectives for interpretation of results. Computer software excel was used for analysis.

Natural enemies collected from different study areas and by different collection methods were sorted out into different orders and families. Total number of inviduals collected under each family of natural enemies were recorded. The biodiversity indices namely Simpsons index, Shannon index and Evenness indices was calculated by using software PAST (version 3.11).

3. Results and Discussion

3.1 Status of natural enemies in three study areas

The total of 563.33 natural enemies were collected from Vijayapur (Study area-1) out of which 152.55 were coccinellids (Coccinellidae), 94.65 syrphids (Syrphidae) 55.80 ichneumonids (Ichneumonidae), 115.90 pentatomids bugs (Pentatomidae) and 144.43 chrysopids and hemerobids (Chrysopidae and Hemerobidae) through three different methods. Similarly from Aliyabad (study area -2) a total of 1035.55 natural enemies were collected in which 346.85 were coccinellids (Coccinellidae), 117.30 syrphids (Syrphidae), 128.65 ichneumonids (Ichneumonidae), 207.20 pentatomid bugs (Pentatomidae) and 235.55 chrysopids and hemerobids (Chrysopidae and Hemerobidae). In Tikota (study area-3) total of 1466.80 natural enemies were recoeded out of which 624.25 coccinellids (Coccinellidae), 160.40 syrphids (Syrphidae), 166.00 ichneumonids (Ichneumonidae), 256.80 pentatomid and mirid bugs (Pentatomidae and Miridae) were collected. This indicates that the highest number of natural enemies were recorded from Tikota followed by Aliyabad and Vijayapur (Table 1).

3.2 Bio diversity of families of natural enemies in three locations

Several studies in the recent past have recommended that variation in the biodiversity between the ecosystem and between locations and is influenced by both biotic and abiotic factors and in agricultural ecosystems farming practices greatly influence the bio diversity of insects. With this in view, the objective studied was to identify the important natural enemies of the grape pests to determine the family diversity under Vijayapur (Study area-1), Aliyabad (Study area- 2) and Tikota (Study area-3).

The diversity of natural enemy families showed great variation between three locations. The Simpson index values were 0.76, 0.79 and 0.81, Shannon index values were 1.68, 1.70 and 1.73 and Evenness were 0.96, 0.93 and 0.87 for study area-1, 2 and 3 respectively (Table 2).

3.3 Relative abundance of different families of natural enemies from three different study areas

Among the natural enemies collected throughout the study period maximum percentage of natural enemies are recovered under family Coccinellidae (27.00 %), followed by Pentatomidae (21.00 %), Syrphidae (17.00 %), Chrysopidae (16.00 %), Ichneumonidae (10.00 %) and Hemerobidae (9.00 %) in Vijayapur (Study area-1) and in study area -2 Coccinellidae (37.00 %), followed by Pentatomidae (20.00 %), Syrphidae (8.00 %), Chrysopidae (14.00 %), Ichneumonidae (11.00 %) and Hemerobidae (10.00 %). In study area -3 Coccinellidae (42.00 %), followed by Pentatomidae (10.00 %) Miridae (8.00 %), Syrphidae (11.00 %), Chrysopidae (11.00 %), Ichneumonidae (11.00 %) and Hemerobidae (7.00 %) (Table 3).

3.4 Relative abundance of predators and parasitoids

A total of 2715.23 and 350.45 predators and parasitoids were recorded across three location respectively. The predators were highly abundant (89.00 %) compared to parasitoids (11.00 %).

Most biological control agents, including predators, parasitoids and spiders, at work in the agricultural and urban environments are naturally occurring ones, which provide excellent regulation of many pests with little or no assistance from humans. The existence of naturally occurring biological control agents is one reason that many plant-feeding insects do not ordinarily become economic pests. The importance of such agents often becomes quite apparent when pesticides applied to control one pest cause an outbreak of other pests because of the chemical destruction of important natural enemies. There is great potential for increasing the benefits derived from naturally occurring biological controls, through the elimination or reduction in the use of pesticides toxic to natural enemies (Wakeil *et al*., 2013) [18].

The populations predators declined by 68.4 per cent during the last decades and many parasitoids have been eliminated from grape ecosystem. The negative effect of synthetic insecticides resulting from their uniformed cues include environmental and human health problems apart from direct toxic effects, insecticides may interfere with the feeding behavior as repellents, inhibitors or olfactory disruptor of certain natural enemies. This compound also cause disruption of six pheromone communication of bio control agent. Residues of insecticides may cause the sub lethal effect like reduced hatching, feeding capacity, fecundity and adult emergence. However, most of the studies showed that sub lethal effects can severly reduces the performance of biological control agents (Desneurx *et al.,* 2007)[4]. In addition to the negative effects of insecticides, residues of persistence compounds can exert their lethal and sub lethal effects on the natural enemies for a longer period of post application (Hewa *et al*., 2003) [7].

Herbivore induced plant volatiles (HIPVs) constitute important cues for parasitoids and predators to find prey or hosts. Undamaged plants emit relatively low levels of volatiles. Upon herbivore, plants emit an induced blent of volatiles of different chemicals classes produced through a variety of bio synthetic pathways. This blend is used by predators and parasitoids as a reliable and well – detectable cue to find herbivore –infested plant (Hare, 2011)[6].

Michely *et al.* (2012) who reported that orientation using visual cues, principally colours (Yellow sticky trap), for habitat or host detection has been reported for several parasitoids families, such as Aphelinidae, Aphididae, Broconidae, Cynipidae, Encyrtidae, Ichneumonidae and Pteromalidae [13].

Joshi *et al*. (2012) stated sampling techniques that provided accurate assessment of coccinellid density critical for evaluation and it include dislodgement (sweep net) passive collection (trap) or visual estimation. Study yielded 23 coccinellids species, belonging to 16 genera, 5 tribes and families [9].

This studies clearly indicated that diversity of natural enemies varied between three locations with highest in Tikota followed by Aliyabad and Vijayapur. From the results it is also evident that though the ecosystems are similar, diversity is influenced by pest load, land use practices and pest management practices and climatic conditions.

This is supported by the studies on input usage pattern done during the study period. The studies recorded maximum number of pesticides and maximum number of sprays at Vijayapur followed by Aliyabad and Tikota. This is reflected in the values of diversity indices where in highest values of Simpson and Shannon indices were recorded in Tikota followed by Aliyabad and Vijayapur.

Different diversity indices were used in present studies. Each index has its own merit and demerit. Simpsons index of diversity (1-D) represents the probability that two individuals randomly selected from a sample will belonging to different species. The values range between 0 and 1, the greater the value greater the sample diversity. Simpsons index is heavily weighed towards the most abundant species in the sample while being less sensitive to species richness. Shannon index accounts for both abundance evenness of the species present in the community. Shannon diversity is the most widely used index for comparing diversity between various habitats (David and Randa, 2014) [3].

In the present study Simpson index and Shannon index values were higher in Tikota. So it represented highest diversity of natural enemies.

Evenness of 1 indicates that all the species are evenly distributed in ecosystem and ecosystem is in good condition. In the present study highest evenness values nearer to 1 are recorded in Vijayapur (0.96) followed by Aliyabad (0.93) which indicates that species distribution is uniform and Tikota recorded lowest evenness value (0.87).

Relative abundance is a component of bio diversity and refers to how common or rare a species is relative to other species in a defined location or community.

The highest abundance was recorded for coccinellids and lowest abundance was recorded for hemerobids. Among the total natural enemies maximum coccinellids were recorded follow by chrysopidae and hemerobidae, pentatomidae and miridae, syrphidae and Ichneumonidae. This may be again due to variations in pest load, land use practices and pest management practices and climatic condition and variation in the response of natural enemies to the cues.

In present studies maximum number of predators were recorded compare parasitoids due to the fact of that volatile mosaic may be exploited differentially by different parasitoid species, in relation to species traits such as sensory ability to perceive volatiles and the physical ability to move towards the source.

Gouinguen *et al.* (2005) who reported that species may differ in their ability to detect volatile compounds, which impact their ability to discriminate between volatile blends, and the distance from which they can track volatile – emitting plants. The minimum volatile concentration eliciting a behavioural response may varies between parasitoids species. Host-specific parasitoids may be more mobile and sensitive to specific volatiles than are parasitoids with awider host range [5].

Farmers highly depend on the use of broad-spectrum insecticides to control pests which can damage the populations of natural enemies, reducing the cost-effectiveness of insecticide investment if unaccounted for in treatment decisions (Zhang and Swinton, 2009) [19].

The present findings similar with the results of Ke Zhou *et al*. (2014) who reported that farmers' pest management practices such as the amount and timing of insecticide use significantly affect ladybeetle densities and the community structure and landscape surrounding agricultural fields also influences the abundance and activity of coccinellid species [10].

Table 1: Status of natural enemies in three study areas

Families	Vijayapur (SA-1)*	Aliyabad (SA-2)*	Tikota (SA-3)**
Coccinellidae	152.55	346.85	624.25
Syrphidae	94.65	117.30	160.40
Ichneumonidae	55.80	128.65	166.00
Pentatomidae and Miridae	115.90	207.20	256.80
Chrysopidae and Hemerobidae	144.43	235.55	259.35
Total	563.33	1035.55	1466.80

Penatomidae*, Pentatomidae and Miridae**

Table 2: Diversity of natural enemies of grape ecosystem of three study areas

SI. No.	Study areas	Diversity indices		
		Simpsons index (1-D)	Shannon index (H)	Evenness (e)
1.	Vijayapur	0.76	1.68	0.96
2.	Aliyabad	0.79	1.70	0.93
3.	Tikota	0.81	1.73	0.87

Table 3: Relative abundance of different families of natural enemies from three different study areas

Families	Relative abundance (%)		
	Vijayapur (SA-1)	Aliyabad (SA-2)	Tikota (SA-3)
Coccinellidae	27.00	37.00	42.00
Pentatomidae and	21.00	20.00	10.00
Miridae	-	-	8.00
Syrphidae	17.00	8.00	11.00
Chrysopidae	16.00	14.00	11.00
Ichneumonidae	10.00	11.00	11.00
Hemerobidae	9.00	10.00	7.00

4. Conclusion

The experiment was mainly conducted in three locations namely Vijayapur, Aliyabad and Tikota wherein the highest number of natural enemies were recorded from Tikota followed by Aliyabad and Vijayapur. Diversity indices of families of natural enemies varied between three study areas. Relative abundance of different families of natural enemies from three different study areas showed variation.

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Appendix I: Questionnaire Documentation of inputs usage pattern

S. No	Particulars
1.	Name of the farmer:
2.	Village:
3.	Taluk / District:
4.	Area under grapevine particular to that farmer:
5.	Cultivars being used:
6.	Age of the orchard:
7.	Remarks

Appendix II: Current pesticide usage pattern as revealed by grape growers in Vijayapur (Study area-1)

S. No.	Pesticide name	Dose	Toxicity Triangle	Broad classification	Trade name/Brand name
1.	Imidacloprid 17.8 SL	0.30 ml/L	Yellow	Insecticide	Confidor
2.	Acetamiprid 20 SP	0.15 gm/L	Yellow	Insecticide	Pride/Rider/Tata manic/ Rapid
3.	Boron + Copper + Iron + Manganese+Molybdenum + Zinc	1.00gm/L	Blue	Micronutrient	Librel-TMX
4.	Fipronil 5 SC	0.05g/L	Yellow	Insecticide	Regent
5.	Bordeaux mixture	3.00gm/ L	Blue	Fungicide	Farm preparation
6.	Lambda-cyhalothrin 5 EC	0.50 ml/ L	Yellow	Insecticide	Karate
7.	Thiamethoxam 25 WG	0.25 gm/L	Blue	Insecticide	Actara/Extra super
8.	Dimethoate 30 EC	1.00 ml/L	Yellow	Insecticide	Rogar
9.	Dichlorovos 76 EC	2.00 ml/L	Red	Insecticide	Nuvan
10.	Methomyl 40 SP	1.00 gm/L	Red	Insecticide	Lannate
11.	Emamectin benzoate 05 SG	0.22 g/L	Blue	Insecticide	Proclaim
12.	Carbendazim 50 WP	2.00 gm/L	Blue	Fungicide	Bavistin
13.	Spiromecifen 240 SC	1.00 ml/L	Yellow	Acaricide	Oberon
14.	Azoxystrobin 23 % SC	200 ml/acre	Green	Fungicide	Amistar

15.	Difenconazole 25 EC	0.50 ml/L	Blue	Fungicide	Score
16.	Sulphur 80 WG	2.00 gm/L	Green	Fungicide, Acaricide	Sulfex/Wetsul/ Macrosul
17.	Cymoxanil 8% + Mancozeb 64% (curzate M8)	2.00 gm/L	Blue	Fungicide	Curzate M8
18.	Chlorpyriphos 20 EC	1.00 ml/L	Yellow	Insecticide	Looper/Dursban/Anth 50
19.	Mancozeb 75 WP	2.00 g/L	Green	Fungicide	Manzate/ Indofil M-45, /Dithane M-45
20.	Azoxystrobin 23 % SC	200 ml/acre	Green	Fungicide	Amistar
21.	Ziram 27 SC	3.50 ml/L	Blue	Fungicide	Cumin L
22.	Copper oxy chloride50 WP	2.00gm/L	Blue	Fungicide	Blitox
23.	Copper hydroxide 77 WP	2.00gm/L	Yellow	Fungicide	Kocide 101
24.	Dinocap 48 EC	0.30 ml/L	Green	Fungicide, Acaricide	Karathane
25.	Cylex	1.00gm/100L	Blue	Growth regulator	6-BA
26.	Gibberrelic acid	20.00 ppm	Green	Growth regulator	ProGibb 4%
27.	Neem oil 5%	2.00 ml	Green	Plant product	Econeem plus/ Neemazal

Appendix III: Current pesticide usage pattern as revealed by grape growers in Aliyabad (Study area-2)

S. No	Pesticide name	Dose	Toxicity triangle	Broad classification	Trade name/Brand name
1.	Imidacloprid 17.8 SL	0.30 ml/L	Yellow	Insecticide	Confidor
2.	Acetamiprid 20 SP	0.15 gm/L	Yellow	Insecticide	Pride/Rider/Tata manic/ Rapid
3.	Boron + Copper + Iron + Manganese + Molybdenum+ Zinc	1.00 gm/L	Blue	Micronutrient	Librel-TMX
4.	Fipronil 5 SC	0.05g/L	Yellow	Insecticide	Regent
5.	Bordeaux mixture	3.00gm/ L	Blue	Fungicide	Farm preparation
6.	Thiamethoxam 25 WG	0.25 gm/L	Blue	Insecticide	Actara/Extra super
7.	Dimethoate 30 EC	1.00 ml/L	Yellow	Insecticide	Rogar
8.	Dichlorovos 76 EC	2.00 ml/L	Red	Insecticide	Nuvan
9.	Spiromecifen 240 SC	1.00 ml/L	Yellow	Acaricide	Oberon
10.	Azoxystrobin 23 % SC	200 ml/acre	Green	Fungicide	Amistar
11.	Difenconazole 25 EC	0.50 ml/L	Blue	Fungicide	Score
12.	Sulphur 80 WG	2.00 gm/L	Green	Fungicide, Acaricide	Sulfex/Wetsul/ macrosul
13.	Cymoxanil 8% + Mancozeb 64% (curzate M8)	2.00gm/L	Blue	Fungicide	Curzate M8
14.	Chlorpyriphos 20 EC	1.00 ml/L	Yellow	Insecticide	Looper/Dursban/Anth 50
15.	Mancozeb 75 WP	2.00 g/L	Green	Fungicide	Manzate/ Indofil M-45, /Dithane M-45
16.	Azoxystrobin 23 % SC	200 ml/acre	Green	Fungicide	Amistar
17.	Ziram 27 SC	3.50 ml/L	Blue	Fungicide	Cumin L
18.	Copper oxy chloride50 WP	2.00 gm/L	Blue	Fungicide	Blitox
19.	Copper hydroxide 77 WP	2.00 gm/L	Yellow	Fungicide	Kocide 101
20.	Cylex	1.00gm/100 L	Blue	Growth regulator	6-BA
21.	Gibberrelic acid	20.00 ppm	Green	Growth regulator	ProGibb 4%
22.	Neem oil 5%	2.00 ml	Green	Plant product	Econeem plus/ Neemazal

Appendix IV: Current pesticide usage pattern as revealed by grape growers in Tikota (Study area- 3)

S. No	Pesticide name	Dose	Toxicity Triangle	Broad classification	Trade name/Brand name
1.	Imidacloprid 17.8 SL	0.30 ml/L	Yellow	Insecticide	Confidor
2.	Acetamiprid 20 SP	0.15 gm/L	Yellow	Insecticide	Pride/Rider/Tata manic/ Rapid
3.	Boron + Copper + Iron + Manganese + Molybdenum + Zinc	1.00gm/L	Blue	Micronutrient	Librel-TMX
4.	Fipronil 5 SC	0.05g/L	Yellow	Insecticide	Regent
5.	Bordeaux mixture	3.00gm/ L	Blue	Fungicide	Farm preparation
6.	Lambda-cyhalothrin 5 EC	0.50 ml/ L	Yellow	Insecticide	Karate
7.	Thiamethoxam 25 WG	0.25 gm/L	Blue	Insecticide	Actara/Extra super
8.	Dichlorovos 76 EC	2.00 ml/L	Red	Insecticide	Nuvan
9.	Emamectin benzoate 05 SG	0.22 g/L	Blue	Insecticide	Proclaim
10.	Spiromecifen 240 SC	1.00 ml/L	Yellow	Acaricide	Oberon
11.	Cymoxanil 8% + Mancozeb 64% (curzate M8)	2.00 gm/L	Blue	Fungicide	Curzate M8
12.	Chlorpyriphos 20 EC	1.00 ml/L	Yellow	Insecticide	Looper/Dursban/Anth 50
13.	Azoxystrobin 23 % SC	200 ml/acre	Green	Fungicide	Amistar
14.	Copper oxy chloride50 WP	2.00 gm/L	Blue	Fungicide	Blitox
15.	Copper hydroxide 77 WP	2.00 gm/L	Yellow	Fungicide	Kocide 101
16.	Dinocap 48 EC	0.30 ml/L	Green	Fungicide, Acaricide	Karathane
17.	Cylex	1.00gm/100 L	Blue	Growth regulator	6-BA
18.	Gibberrelic acid	20.00 ppm	Green	Growth regulator	ProGibb 4%
19.	Neem oil 5%	2.00 ml	Green	Plant product	Econeem plus/ Neemazal