Technical Bulletin No. 8

PACKAGE OF PRACTICES FOR MANAGING MAJOR DISEASES AND INSECT PESTS ON GRAPES

भाकृअनुप
ICAR

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PREFACE

Grape cultivation in India faces serious threat from several insect pests and diseases. The major fungal diseases and insect pests include downy mildew, powdery mildew, anthracnose and mealybug and thrips respectively which cause enormous economic losses to grape sector every year.

Use of appropriate pesticide in right dose at right time holds the key for effective pest management. Indiscriminate use of pesticides not only add to the cost of production significantly, but also results in pesticide residues in the final produce and also in soil and water.

This technical bulletin covers the practices including IPM package to be followed at veraison stages of grape cultivation for the management of major diseases and pest prevalent in Indian conditions. It covers not only the practices to be followed but also the preventive measures to be taken for effectively implementing those practices.

This bulletin will serve as a guideline for grape growers, State Govt. officers and other stake holders besides grape researchers and students. I acknowledge the guidance and help received from Dr. Mangala Rai, Secretary, DARE and Director General, IACR, New Delhi; Dr. T.P. Rajendran, Assistant Director General (Plant Protection) and Dr. S.N. Pandey, A Assistant Director General (Hort.). I also acknowledge my colleagues Dr. S.D. Sawant, Dr. N.S. Kulkarni, Dr. Indu S. Sawant, and Dr. M. Mani in preparation of this bulletin in short time and Dr. Anuradha Upadhyay for getting it printed.

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Date: March 2007

(P.G. ADSULE)
Director

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1.1 Downy mildew (*Plasmopara viticola* (Berk. & Curt.) Berl. & de Toni)

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Remove abnormal un-harvested bunches from vines and burn them. 	Immediately after harvesting is over.	Downy mildew infected bunch contains oospores in dead tissue which helps in survival of pathogen during adverse conditions and act as primary source of disease inoculum.	Symptomatic bunches left in vineyard are manually collected and disposed in compost pit.	Do not allow the infected bunches to remain in vineyards.	Bunches will decompose and add oospore inoculum in vineyard soil.
Remove dead wood present on arms and paste cut surfaces with Bordeaux paste. or Spray vineyard with 1 % Bordeaux mixture.	Within 1-2 days after pruning.	Dead wood harbour the inoculum of downy mildew and *Botryodiplodia.* Pasting on cut surfaces will avoid secondary infection of wood rotting fungi.	Dead wood is removed with the help of knife and pasting is done with flat paint brush.	Application of fungicide should not be delayed more than 2 days of pruning.	Cell sap oozes from cut surfaces and provides good media for fungal spore germination and infection takes place within 2-3 days.
Remove all shoots emerging from the crown near ground. Shoots hanging from trellises towards ground should be tied on trellises or can be removed if they are extra.	During June and after onset of monsoon. 	To avoid nearness of tender leaves and shoots to soil.	If the shoots sprouts are noticed they are rubbed off Shoots hanging from trellises are tied on wires with the help of sutli (jute thread).	Do not allow such shoots after July.	Downy mildew inoculum in soil becomes active after few major rains in June – July.

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray Bordeaux mixture 0.5 % or Copper hydroxide 2.0 g/l or COC 3.0 g/l at 15-20 days interval to cover all rainy period. On an average about three to four sprays may be needed to cover all rainy days from June to September.	After the outbreak of monsoon, and during short break after continuous rainy periods.	To control downy mildew.	Sprayers with HTP pump can be used. About 400 l of water should be used per acre to achieve good coverage.	pH of the Bordeaux mixture should be 7 to 7.5 and not be allowed below this level. Do not spray any acidic substances after the sprays of copper fungicides.	Acidic media makes more copper ions available to plant and more uptake of copper leads to chlorosis and necrosis on leaves due to copper toxicity.

1.2 Powdery mildew (*Uncinula necator* (Schw.) Burr.)

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray Sulfur 2.0 g/l or Potassium bicarbonate 5.0 g/l if powdery mildew is noticed.	During last week of May.	To control Powdery mildew as it usually appears if dense canopy is developed during summer, especially after flood irrigation.	Sprayers with HTP pump can be used. During May only 80-90 % canopy will be developed, hence about 320-360 l of spray volume is required.	Do not spray Sulfur if temperatures are very high (35 – 40^{o}C).	In high temperatures sulfur may cause phytotoxicity.
Spray Sulfur 2.0 g/l or Dinocap 0.25 ml/l or Potassium bi carbonate 10.0 g/l.	If cloudy weather prevails without rains more than 2 mm rain for 3 to 5 days during June to August.	To control powdery mildew.	Sprayers with HTP pump can be used. Canopy will be full and 400 l spray volumes will be needed.	Do not spray Dinocap if tender shoots are present in canopy.	Dinocap is known to cause scorching of tender shoots only.

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Use of non-ionic spreaders along with potassium bicarbonate @ 1.0 ml/4-5 l of spray solution.	Whenever potassium bicarbonate is used as spray.	To improve the bio-efficacy of potassium bicarbonate.	Mix in spray solution before spraying @ 2ml/10 l.	-	-
One or two sprays of Bordeaux mixture suggested for control of downy mildew can be given after mixing sulfur @ 2.0 g/l.	After onset of monsoon, but if very low incidence of powdery mildew is seen.	To control powdery mildew.	Sprayers with HTP pump can be used. Canopy will be full and 400 l spray volumes will be needed.	pH of the Bordeaux mixture needs to be adjusted to 7 after mixing sulfur and not before mixing sulfur.	Sulfur is acidic and its addition will decrease the pH of Bordeaux mixture and it will turn phytotoxic.

1.3 Anthracnose (*Elsinoe ampelina* (de Bary) Shear)

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Remove all pruned material away from vineyard and dispose in compost pit. 	As early as possible after pruning.	If pruned material is retained close to vineyard and open on soil surface, it may get wet with rain and air borne spores of the pathogens such as *Elsinoe* and *Botryodiplodia* will again infect new shoots.	Collect the pruned waste in tractor trolley and dump it in compost pit.	Do not allow the pruned waste near vineyards during rains.	Anthracnose spores can be developed on infected pruned cane in wet condition to spread the disease in vineyard.
Broad spectrum fungicide Mancozeb (6.0 g/l) or Carbendazim (2.0 g/l) along with hydrogen cyanamide used as pasting on cane for uniform sprouting.	During pasting of canes with hydrogen cyanamide.	To kill left over inoculum from cane effectively.	Swabbing on canes.	-	-

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray Carbendazim 50 WP 1.0 g/l.	Only if summer showers are received after emergence of bud.	To control anthracnose on tender shoots. New infection of anthracnose takes place only on tender shoots and leaves, in wet conditions.	- do -	pH of the water used for spray should be acidic i.e less than 7	Alkaline media led to alkaline hydrolysis of the carbndazim. Products of alkaline hydrolysis are less fungi-toxic.
Add 25 to 30 g citric acid per 100 l of spray water.	Only if water used for carbendazim spray is having pH above 7.5.	To avoid alkaline hydrolysis of the carbendazim.	Dissolve citric acid in water and stir well for solubility.	Do not add citric acid before mixing carbendazim.	Carbendazim if added in alkaline water hydrolyses fast, hence if citric acid is added afterwards the purpose will not be served.
Spray Copper hydroxide 2.0 g/l or COC 3.0 g/l, Ziram 27 SL, 4 l/ha, or Chloronthalonil 2 kg/ ha.	7 -10 days after the spray of systemic fungicide carbendazim.	Carbendazim is highly prone to development of resistance in pathogen. Use of non-systemic fungicides will reduce such possibility.	Sprayers with HTP pump can be used. Canopy will be full and 400 l spray volumes will be needed.	-	-
Sprays of copper fungicides suggested for control of downy mildew will also control anthracnose					
Spray formulations of *Trichoderma* 2 to 5 ml/l.	One or two sprays at 10 days interval may be given when high humidity prevails during September – October.	To control infection of *Alternaria*, and C*ladosporium* on leaves and to delay leaf fall. 	Mix the formulation in water and spray with regular sprayer, preferably during evening to avoid harshness on afternoon sunlight.	Avoid fungicide sprays after the sprays of fungal bio-control agents.	*Trichoderma* on foliar plant parts will be killed.
Burry all removed leaves in root zone to improve soil population of *Trichoderma.*	Immediately after leaves are removed before forward pruning.	To increase soil population of *Trichoderma.* It will be useful in reducing inoculum of downy mildew and other weak pathogens like *Alternaria.*	Collect the leaves by sweeping and burry in soil in rhizosphere area.	Do not practice this in vineyard with heavy incidence of downy mildew.	Downy mildew infected leaves will add oospore inoculum in soil which is not desirable.

2. Major diseases – after forward pruning (October to April):

2.1 Downy mildew

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Downy mildew infected leaves should be selectively collected and disposed in compost pit.	Just before forward pruning.	To reduce inoculum of downy mildew in vineyard.	Collect infected leaves and dispose in compost pit.		
Spray 1% Bordeaux Mixture as preventive measure.	Within 1-2 days of forward pruning.	To reduce general disease inoculum on plant surface.	Sprayers with HTP pump can be used. Canopy will be only 70% and 280 l spray volumes will be needed.	Application of fungicide should not be delayed more than 2 days of pruning.	Cell sap oozes from cut surfaces and provides good media for fungal spore germination and infection takes place within 2-3 days.
Mix mancozeb 6.0 g/l with Hydrogen cynamide solution for swabbing canes.	At the time of pasting canes with Hydrogen cyanamide.	To reduce inoculum of downy mildew from canes effectively.	Swabbing on canes.	-	-
Spray 0.5 % Bordeaux mixture in un-pruned block close to pruned block.	Whenever un-pruned block in close vicinity of pruned block is not likely to be pruned within 5-8 days.	To avoid spread of active disease inoculum from un-pruned block. 	Sprayers with HTP pump can be used. Canopy will be 100% and 400 l spray volumes will be needed.	The spray should be given much before new spouts are emerged in pruned block.	If the spray is done after new shoots are developed in pruned plot, it would have already got contaminated with inoculum from un-pruned plot.

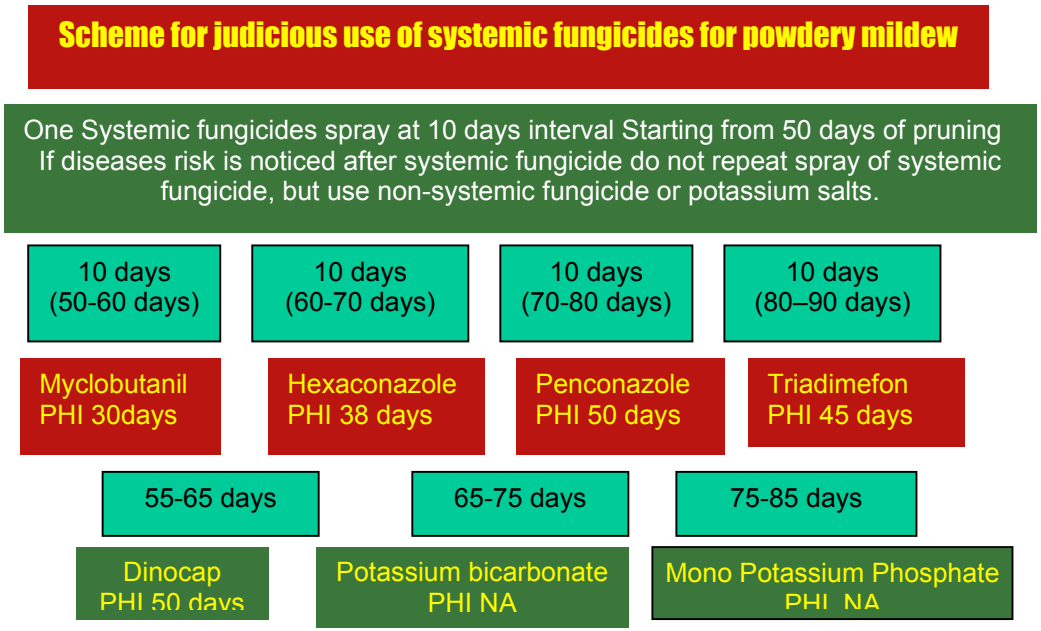
What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray any of the fungicides (Metalxyl + Mancozeb) 72 WP, 2.5 g/l or (Cymoxanil + Mancozab) 72 WP, 3.0 g/l or Fosetyl Al 3.0 g/l or any formulation containing potassium salt of phosphonic acid 3.0 ml/l or Dimethomorph 50 WP, 0.8 g + mancozeb 75WP 2.0 g/l as tank mix, or Azoxystrobin 23SC 200 ml/acre. Total three fungicide sprays to cover 15 to 30 days.	First spray at three leaf stage (i.e. 15 days after forward pruning)  and then two more sprays at 5-10 days interval coinciding with 5 and 7 leaf stages.  	The disease first appears at three leaf stages and can be very destructive and fast spreading till fruitset (i.e. up to 50 days after pruning) and preventive sprays are essential. Presence of free moisture on leaves or bunch for 2 to 3 hours after sunrise is needed for new infection. Hence spray is required only if such conditions are present.	Sprayers with HTP pump can be used. Canopy will be only 70 % at first spray and 80 % at subsequent sprays. Hence 280 l, and 320 l spray volumes will be needed for respective sprays.	Do not spray same fungicides in successive sprays.	Application of same fungicide successively will give opportunity to pathogen to develop resistance.
Spray copper fungicides (Copper hydroxide 2.0 g/l or COC 3.0 g/l) or any other non systemic fungicides viz. captan , mancozeb, chlorothalnil @ 2.0 g/l after 3 to 4 days after 2nd or 3rd spray of systemic fungicides suggested above. If wet conditions do not prevail, one of the suggested sprays of systemic fungicide could be replaced by spray of non-systemic fungicide.	Spray as preventive sprays when interval between two systemic fungicides suggested above is longer than 10 days due to unfavourable weather conditions.	Use of non-systemic fungicides help in preventing resistance in systemic fungicides.	Sprayers with HTP pump can be used. Canopy will be 80% hence, 320 l spray volumes will be needed.	-	-

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray Fosetyl Al 3.0 g/l in solution of GA prepared for spray.	Along with GA sprays given after 25 -30 days of pruning.	GA sprays increase succulence in new shoots as well as humidity in the canopy, and increase the chances of downy mildew infection. So for the control of downy mildew Fosetyl Al is useful. Fosetyl Al solution is acidic and improves GA uptake.	Normally 2 to 3 sprays of GA are given. Only one or two of these sprays, preferably second and third spray may be given along with Fosetyl Al.	-	-
Add any of the systemic fungicides suggested above for the control of downy mildew in GA solution used for dipping at recommended spray concentration.	At the time of GA dipping given after fruit-set.	To prevent spread of the downy mildew selectively on bunches through GA solution used for dipping. While doing GA dipping of bunches, if bunch infected with downy mildew is unknowingly dipped in the solution, the solution is contaminated with spores and selectively spreads downy mildew on bunches.	The fungicide is mixed in GA solution prepared for dipping. 	-	-

2.2 Powdery mildew

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray Sulfur 2.0 g/l or Spray Penconazole 0.5 ml/l (PHI 50 days), or Flusilazole 25 ml/l (PHI 50 days),or Tridemefon 1.0 g/l (PHI 45 days). Two sprays of one each from the above fungicides may be required to cover the period from flowering to fruit set.	Flowering to fruit-set (about 35 to 50 days of pruning).	To control powdery mildew. Many times if cloudy climate prevails powdery mildew can develop sporadically in vineyards leading to development of inoculum. Infection of powdery mildew on rachis near maturity develops only when early infection of powdery mildew during flowering to fruit-set is noticed in vineyards.	Sprayers with HTP pump can be used. Canopy will be 80% hence, 320 l spray volumes will be needed.	Avoid spraying sulfer after fruit set. Sprays of systemic fungicide with long PHI (Pre Harvest Interval) are preferred during this period.	Sulfur may cause stains on berries resulting in low market value. Spay of low PHI fungicide will increase the risk of their residue when used later. And fungicides with high PHI cannot be used late in the season.
Spray penconazole 0.5 ml/l (PHI 50 days) or tridemefon 1.0 g/l (PHI 45 days) or hexaconazole 1.0 ml/l (PHI 38 days) or myclobutanil 0.4 g/l (PHI 30 days). Apply one spray of each of the fungicides suggested above at an interval of 10 days to cover 40 days period. While deciding sequence, PHI and expected time of harvest may be taken in to consideration.	Four sprays at 10 days interval from fruit-set to veraison (50 to 60 days after pruning).	After 50 days of forward pruning the temperature drops down considerably. The canopy becomes dense and microclimate within is most suitable for development of powdery mildew. Cloudy days with less light and relatively warmer temperature (20-25^{o}C) are most favourable for disease development. During these 40 days bunch develops and it is physiologically most active. Hence, it is most appropriate time for use of systemic fungicides. Use of non-systemic fungicides during this period protect leaves from powdery mildew but fail to protect bunches. Use of systemic fungicides during this period is thus unavoidable.	Sprayers with HTP pump can be used. Canopy will be 100% hence, 400 l spray volumes will be needed	Spray of any of the fungicide should not be repeated during this period.	Risk of residue will increase.

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Any of the systemic fungicides mentioned above can be sprayed after mixing potassium bi carbonate 5.0 g/l.	-do-	Use of non-systemic fungicide will help in reducing chances of resistance development for systemic fungicides Use of potassium bicarbonate alongwith systemic fungicides improves the curative action and provides better control of the disease.	Sprayers with HTP pump can be used Canopy will be 100% hence, 400 l spray volumes will be needed.	Do not spray potassium bicarbonate after veraison.	Bunches may turn yellowish and mature early.



What to do	When to do	Why to do	How to do	What not to do	Why not to do
Between two sprays of systemic fungicides non-systemic fungicide Dinocap 30 ml/100 l water can be sprayed.	Up to 65-70 days after pruning.	Use of non-systemic fungicide will help in reducing chances of resistance development for systemic fungicides.	Sprayers with HTP pump can be used. Canopy will be 100%, hence, 400 l spray volumes will be needed.	Do not spray Dinocap if tender shoots are present in canopy. Do no spray after 80 days of pruning.	Dinocap is known to cause scorching of tender shoots only. PHI is 50 days.
The sprays of potassium sources potassium nitrates / potassium sulphate / monopotassium phosphate @ 2-3 g/l can be given between two sprays of systemic fungicides suggested above.	70 to 80 days of pruning. 	To ensure that vines do not suffer from potassium deficiency. Potassium deficiency in vines leads to more infection of powdery mildew. Potassium deficiency cause upward curling of leaves. The curled leaves are more susceptible to disease, and inside curled area better microclimate for powdery mildew development is created.	Sprayers with HTP pump can be used Canopy will be 100% hence, 400 l spray volumes will be needed.	Do not give more than one spray of Monopotassium phosphate.	Bloom of the bunches may be reduced.
Spray systemic fungicide Myclobutanil 0.4 g/l purpose myclobutanil is used for spray once after 50 – 60 days of forward pruning and then again after 90 days of forward pruning.	Can be sprayed till 100-110 days after pruning.	To control powdery mildew infection on rachis.	Sprayers with HTP pump can be used. Canopy will be 100% hence, 400 l spray volumes will be needed.	It can be used provided that during last 30 days the same fungicide was not sprayed and there are at least 30 days left for harvesting.	If the conditions are not fulfilled there will be more residue risk.

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray HP Grape Spray oil 5 – 7 ml/l or Tricure (Azadirachtin 0.03 %) 5 ml/l.	If less than 30 days are left for harvest and powdery mildew on rachis is noticed.	Control powdery mildew on rachis. HP grape spray oil contains mineral oil, while Tricure contains neem extract with 0.03% azadirechtin. Both these products are safe and permitted even for organic farming, and hence can be used near harvesting without the risk of residue.	Sprayers with HTP pump can be used. Canopy will be 100% hence, 400 l spray volumes will be needed.	Before application of these material it is advisable to try on few bunches to ensure that there is no possibility of scorching or spots on berries.	These products do not cause scorching or spots, but due to reaction with residues of previous sprays it is possible.

2.3 Post harvest berry rots caused by fungi (*Cladosporium, Alternaria , Botryodiplodia, Rhizopus*, and *Aspergillus)*

What to do	When to do	Why to do	How to do	What not to do	Why not to do
Spray Iprodion 2 g/l (PHI 7 days) for control of post harvest berry rot.	7-15 days before harvesting.	For chemical control of post harvest berry rot.	Sprayers with HTP pump can be used. Canopy will be 100% hence, 400 l spray volumes will be needed.	Do not spray 5 days before and after spray of *Trichoderma.*	It will reduce the *Trichoderma* population on berries.
Pre harvest spray treatment of *Trichoderma* spp. with liquid formulations @ 5 ml/l.	Two sprays about 15 days before harvest at weekly interval. In the event of rains application of *Trichoderma* can be preponed.	Control of post harvest berry rots. It also helps I bio-remediation of pesticide residue on berries. 	Sprayers with HTP pump can be used. Canopy will be 100% hence, 400 l spray volumes will be needed.		

Note: NRC for Grapes has also developed disease forecasting based disease management strategies. Risk of different diseases is estimated in prevailing climate at three days interval and decision on spray of fungicide is taken only if the risk of disease is predicted. Such systems have already been installed at different KVK and co-operative societies exporting grapes. Growers may collect the information from the nearest accessible unit before taking decisions on above suggested fungicide sprays. It will be useful to them to reduce number of fungicide sprays by avoiding sprays when disease risk is low.

3. Major insect pests - after foundation pruning (April to October)

3.1 Mealybugs

What to do	When to do	Why to do	How to do	What not to do	Why not do
Removal and destruction of loose bark and swabbing of stem and arms with 2 ml of Dichlorvos 76 EC + 2 g of fish oil resin soap in a litre of water.	Immediately after pruning.	This is done to expose hiding population of mealybugs, eggs of flea beetle and destroy them	Removal of bark is done by using knives and swabbing is done using hand gloves and brush.	Should not dump the removed bark in the vineyard.	Loose bark may carry the population of mealybugs.
 					
Application of sticky bands like 'Track-trap' or 'Bird Tangle Foot' on arms or on main stem before appearance of mealy bugs on canes or bunches.	Immediately after pruning.	This is done to prevent crawlers of mealybugs reaching the bunch and also to prevent movement of ants.	Sticky band application is done mechanically or by hand.	Do not incorporate the pruned material in the soil	Pruned material may contain the population of mealybugs
Removal of weeds and alternate host plants like hibiscus, bhindi, custard apple, guava etc in and nearby vineyards.	Immediately after pruning.	Weeds and alternate host plants helps in harboring insect pests like thrips and mealybugs.	Weeding either by manual weeding/ use of herbicide.	Do not dump the removed weeds and alternate host plants in the vineyard.	Weeds and alternate host plants contain the population of thrips and mealybugs.
Locating of ant colonies and destroy them with drenching of Chlorpyriphos 20 EC @ 2 .5 ml/l or apply Malathion dust @ 25 kg/ac.	Round the year.	Ants helps in spreading of mealybugs and they also interfere with the mealybug predator ladybird beetle and other natural enemies.	Ants management by application of insecticides or by dusting or poison baiting around identified ant hills.	Indiscriminate insecticide application is to be avoided.	Accumulated residues in soil and water could lead to high residue levels in vineyards.

What to do	When to do	Why to do	How to do	What not to do	Why not do
Foliar spray of Methomyl 40 SP @ 1 g/l or Dichlorvos 76% EC @ 2ml/l.	30-45 days after pruning.	To reduce the population of mealybugs.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer according to canopy size.	Do not mix these insecticides with growth regulators without verifying the compatibility.	It leads to phyto-toxicity symptoms.
Spraying of Phosalone 35 EC or Malathian 50 EC 2 ml/l.	45-60 days after pruning.	To reduce the population of mealybugs.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Do not repeat the same insecticide 2-3 times continuously.	It leads to development of resistance in insects.
Release of Australian lady beetle adult/ grub *Cryptolaemus montrouzieri* @ 10,000 per ha / year. 	75-90 days after pruning.	Predators are effective in killing all stages of mealybugs.	Predator release is done @ 5000 beetles/ ha, two times in a season especially during August-September and December-January.	Avoid spraying pesticides.	Pesticides are destructive to beetles.
Foliar spray of *Verticillium lecanii / Beauveria bassiana* ($2x10^8$ cfu/ml) @ 5 g/ ml/l.	105-120 days after pruning during high humid months.	To reduce the population of mealybugs.	Foliar spray of biopesticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Should not mix bio-pesticides and fungicides. Will not be effective in dry months.	Fungicides kill biopesticides. These fungi die off under low humidity levels.

3.2 Flea beetle

What to do	When to do	Why to do	How to do	What not to do	Why not do
Foliar spray of Carbaryl 50 WP @ 2 g/l. 	7-15 days after pruning. 	To reduce the population of fleabeetle.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Carbaryl should not be sprayed after fruit set.	Leads to phyto-toxicity symptoms.

3.3 Thrips and Hoppers

What to do	When to do	Why to do	How to do	What not to do	Why not do
Foliar spray of Imidacloprid 200 SL @ 0.3 ml/l or Thiamethoxam 25 WG @ 0.25 g/l or Lambda-cyhalothrin 05 EC @ 0.5 ml/l. 	60-75 days after pruning. 	To reduce the population of thrips and hoppers.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Same insecticide is not repeated 2-3 times in a season.	It leads to development of resistance in insects.
Foliar spray of Azadirachtin 1% @ 2 ml/l or 5% @ 1 ml/l.	90-105 days after pruning.	Neem formulations deter sap sucking pests from feeding on tender tissues.	Biopesticides and botanicals are sprayed like pesticides.	Should not be mixed with sulphur and copper fungicides.	Leads to phytotoxicity.

4. Major insect pests - after forward pruning (October to April)

4.1 Mealybugs

What to do	When to do	Why to do	How to do	What not to do	Why not do
Removal and destroy of loose bark and swabbing of stem and arms with 2 ml of Dichlorvos 76 EC + 2 g of fish oil resin soap in a liter of water.	Immediately after pruning.	This is done to expose hiding population of mealybugs, eggs of flea beetle and destroy them.	Removal of bark is done using knives and swabbing is done using hand gloves and brush.	Should not dump the removed bark in the vineyard.	Loose bark may carry the population of mealybugs and have to be burnt off.
Application of sticky bands 'Track-trap' or 'Bird Tangle Foot' on arms or on main stem.	Immediately after pruning.	This is done to prevent crawlers of mealybugs reaching the bunch and also to prevent movement of ants.	Sticky band application is done mechanically or by hand.	Do not incorporate the pruned material in the soil.	Pruned material may contain the population of mealybugs and hence should be destroyed.
Removal of weeds and alternate host plants like hibiscus, bhindi, custard apple, guava etc in vineyards.	Immediately after pruning.	Weed and alternate host plants helps in harboring insect pests like thrips and mealybugs.	Weeding either manually or with permitted herbicides.	Do not dump the weeds and alternate host plants in the vineyard.	Weeds and alternate host plants contain the population of thrips and mealybugs and hence should be composted or destroyed.
Locating of ant colonies and destroy them with drenching of Chlorpyriphos 20 EC @ 2.5 ml/l or apply Malathion dust @ 25 kg/ac.	Round the year.	Ants help in spreading of mealybugs and they also interfere with the mealybug predator ladybird beetle and other natural enemies.	Ants management by application of insecticides or by dusting or poison baiting around identified ant hills.	Indiscriminate insecticide application is to be avoided.	Accumulated residues in soil and water could lead to high residue levels in vineyards.

What to do	When to do	Why to do	How to do	What not to do	Why not do
Foliar spray of Methomyl 40 SP @ 1 g/l or Dichlorvos 76% EC 2ml/l.	30-45 days after pruning.	To reduce the population of mealybugs.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Do not keep the dense canopy in the vineyard at this stage.	It favours build up of thrips and mealybugs.
Spraying of Buprofezin 25 SC @ 1000-1125 ml/ha.	45-60 days after pruning.	Effective against mealybugs.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Same insecticide is not repeated 2-3 times in a season.	It leads to accumulation of pesticide residues in the fruit.
Release of Australian lady beetle adult/grub C*ryptolaemus montrouzieri* @ 10,000 per ha / year.	75-90 days after pruning.	Predators are effective in killing all stages of mealybugs.	Predator release is done @ 5000 beetles / ha, two times in a season especially during August-September and December-January.	Avoid spraying pesticides.	Pesticides are destructive to beetles and other beneficials.
Foliar spray of *Verticillium lecanii* or *Beauveria bassiana* ($2x10^8$ cfu/ml) @ 5 g/ ml/l.	90-105 days after pruning.	Biopesticides are effective when the environmental conditions are favourable.	Biopesticides and botanicals are sprayed like pesticides.	Should not mix bio-pesticides and fungicides.	Fungicides kill the biopesticides.
Spraying of Buprofezin 25 SC @ 1000-1125 ml/ha.	105 -120 days after pruning.	Effective against mealybugs.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Should not be used through drip irrigation.	Buprofezin is a contact insecticide and not translocated in to the plants.
Foliar spray of Azadirachtin 1% @ 2 ml/l or 5% @ 1 ml/l.	120-135 days after pruning.	Neem formulations deter sap sucking pests from feeding on tender tissues.	Biopesticides and botanicals are sprayed like pesticides.	Should not be mixed with sulphur and copper fungicides.	Leads to phytotoxicity.

4.2 Fleabeetle

What to do	When to do	Why to do	How to do	What not to do	Why not do
Removal and destroy of loose bark and swabbing of stem and arms with 2 ml of Dichlorvos 76 EC + 2 g of fish oil resin soap in a liter of water.	Immediately after pruning.	This is done to expose hiding population of mealybugs, eggs of flea beetle and destroy them.	Removal of bark is done using knives and swabbing is done using hand gloves and brush.	Should not dump the removed bark in the vineyard.	Loose bark may carry the population of mealybugs and have to be burnt off.
Foliar spray of Carbaryl 50 WP @ 2 g/l.	7-15 days after pruning.	To reduce the population of flea beetle.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Carbaryl should not be sprayed after fruit set.	Leads to phyto-toxicity symptoms.
Foliar spray of Imidacloprid 200 SL @ 0.3 ml/l or Thiamethoxam 25 WG @ 0.25 g/l or Lambda-cyhalothrin 5 EC @ 0.5 ml/l.	15-30 days after pruning.	These are systemic insecticides and effective against sucking insects.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Should not apply excess Nitrogenous fertilizers.	Excess N Encourage the build up sap sucking insects including mealy bugs.

4.3 Thrips and Hoppers

What to do	When to do	Why to do	How to do	What not to do	Why not do
Removal of weeds and alternate host plants like hibiscus, bhindi, custard apple, guava etc in vineyards.	Immediately after pruning.	Weed and alternate host plants helps in harboring insect pests like thrips and mealybugs.	Weeding either manually or with permitted herbicides.	Do not dump the weeds and alternate host plants in the vineyard.	Weeds and alternate host plants contain the population of thrips and mealybugs and hence should be composted or destroyed.

What to do	When to do	Why to do	How to do	What not to do	Why not do
Foliar spray of Imidacloprid 200 SL @ 0.3 ml/l or Thiamethoxam 25 WG @ 0.25 g/l or Lambda-cyhalothrin 5 EC @ 0.5 ml/l.	15-30 days after pruning.	These are systemic insecticides and effective against sucking insects.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer.	Should not apply excess Nitrogenous fertilizers.	Excess N Encourage the build up sap sucking insects including mealy bugs.
Spraying Spinosad 45 SC @ 0.25 ml/l or Emamectin benzoate 0.22 g/l.	60-75 days after pruning.	These are natural products and effective against thrips.	Foliar spray of insecticides is done through tractor mounted high volume sprayer/ knap sack sprayer based on canopy size.	Do not keep the dense canopy in the vineyard. Avoid excess of nitrogenous fertilizers.	Excess nitrogenous fertilizers favour the build up of sucking pests. Balanced fertilizer application is required.

4.4 Stem borers

What to do	When to do	Why to do	How to do	What not to do	Why not do
Injecting vines with 2 ml of Dichlorvos 76% EC. 	60-75 days after pruning. 	To kill the larval stage of stem borer.	Making hole and injecting with syringe.	Healthy trees should not be injecting with insecticide.	Injecting vine acts like only a curative measure.

4.5 Mites

What to do	When to do	Why to do	How to do	What not to do	Why not do
Foliar spray of Azadirachtin 1% @ 2 ml/l or 5% @ 1 ml/l or Difenthiuron 0. 8 g/l.	75-90 days after pruning.	Neem formulations deter sap sucking pests from feeding on tender tissues. Difenthiuron is acaricide.	Biopesticides and botanicals are sprayed like pesticides.	Should not be mixed with sulphur and copper fungicides.	Leads to phytotoxicity.
Foliar spray of Azadirachtin 1% @ 2 ml/l or 5% @ 1 ml/l. 	90-105 days after pruning. 	Neem formulations deter sap sucking pests from feeding on tender tissues.	Biopesticides and botanicals are sprayed like pesticides.	Should not be mixed with sulphur and copper fungicides.	Leads to phytotoxicity.

General precautions:

1. All the doses mentioned above are for high volume sprayers, where normal spray volume is 1000 L/ha.
2. Spray volume can however, be changed as per efficiency of sprayers used and canopy size.
3. Select appropriate spraying appliance according to canopy size and nature of pesticides to be applied.
4. Biopesticides must be sprayed in early morning or late evening i.e. especially in the cool hours.
5. Growers should use only the pesticides which are permitted for use in grapes by Central Insecticide Board, Govt of India / NRC for Grapes, Pune.
6. Growers should not mix any pesticides, growth regulators and any other chemicals without verifying their compatibility.

5. General information about various insect pests of grape

By and large, the major insect pests in the grapes are found to be mealybugs, thrips, fleabeetle, leafhoppers, stem borer and mites in order of their economic damage to the crop. Since the grape is a perennial crop, one has to look after full one year cycle of the crop where both the stages i.e. vegetative growth and fruit development takes place. Considering these facts, the strategy for the management of insect pests is worked out.

i. Mealybugs-*Maconellicoccus hirsutus, Planococcus citri*

Mealybugs are very important insect pests and they occur throughout the year and their management is very crucial near harvest. However, mealybug management can be planned well in advance especially immediately after both April and October pruning.

ii. Thrips- Scirtothrips dorsalis, Rhipiphorothrips cruentatis

Thrips are very important insect pests and they occur throughout the year and their management is very crucial during flowering and berry setting period (November -December).

iii. Fleabeetle-Scelodonta strigicollis

Fleabeetle occurs immediately after both foundation and back pruning and their management is crucial immediately after both pruning.

iv. Leaf hoppers-Arboridia viniferata

Hoppers are very important insect pests and they occur throughout the year and their management is very crucial during flowering period (November -December).

v. Stem borer-Celosterna scabrator

Incidence of stem borer is more after foundation pruning especially during November-January.

vi. Mites-Tetranychus urticae

Mites are becoming important pests in recent years and their management is crucial during December-February months.