Sweet Corn

Strategic Agrichemical Review Process
2011-2014

HAL Projects - MT10029 & VG12081

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Horticulture Australia project no:
MT10029 – Managing pesticide access in horticulture.
VG12081 - Review of vegetable SARP reports.

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Purpose of the report:
This report was funded by Horticulture Australia and the Australian vegetable industry to investigate the pest problem, agrichemical usage and pest management alternatives for the sweet corn industry across Australia. The information in this report will assist the industry with its agrichemical selection and usage into the future.

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Horticulture Australia

Contents

1. Media Summary

A Strategic Agrichemical Review Process (SARP) through the process of a desktop audit and industry liaison assesses the importance of the diseases, insects and weeds (plant pests) that can affect a horticultural industry; evaluates the availability and effectiveness of fungicides, insecticides and herbicides (pesticides) to control the plant pests; determines any 'gaps' in the pest control strategy and identifies suitable new or alternatives pesticides to address the gaps.

Alternative pesticides should ideally be selected for benefits of:

- Integrated pest management (IPM) compatibility
- Improved scope for resistance management
- Sound biological profile
- Residue and trade acceptance domestically and for export.

SARP workshops for sweet corn were conducted in Queensland, New South Wales, Victoria and Western Australia as part of combined vegetable meetings in 2008, 2010 and 2011. The results of the process provide the industry with pesticide options for the future that the industry can pursue for registration with the manufacturer, or minor-use permits with the Australian Pesticides and Veterinary Medicines Association (APVMA).

DISEASE

Diseases identified as high priorities:

Disease (common name)	**Disease (scientific name)**
Java downy mildew	*Peronosclerospora maydis*
Turcicum leaf blight	*Exserohilum turcicum*

As with most minor crops there is a gap in the available fungicides for treatment of major diseases. Growers need further chemistry for alternation to keep disease under control and to reduce the risk of resistance developing.
Growers rely significantly on fungicide treated seed but also require in-crop solutions. It would be helpful if products registered for the control of diseases in the major fruiting vegetables could also be registered of permitted for sweet corn, in particular as MRLs are often already in place for the crop groups.

Growers would additionally like new, particularly soft chemistry, to be considered for sweet corn, although recognising that data gaps will be greater for these.

With limited chemical control options growers are largely dependent on management techniques, including: choosing cultivars which are resistant or tolerant to disease; ensuring weed populations are kept in check and monitored for disease-carrying insects; timing planting to avoid conditions that favour disease, and; crop rotations.

INSECTS

Insects identified as high priorities:

Insect (common name)	**Insect (scientific name)**
Armyworms	*Spodoptera spp.*
Helicoverpa	*Helicoverpa punctigera*

Although there are registrations and permits for a range of pests, there are no chemicals permitted specifically for some lower priority uses. As an example, African black beetle was determined to be a moderate priority in the SARP process but can at times be a major priority in Victoria, where crop losses of 90% have been noted. Growers must rely on control by other chemicals already being used in the crop. This can be difficult when the management strategy is not targeted to the problem.

A range of pests, including: Helicoverpa, cabbage aphid, diamondback moth, green peach aphid, loopers, cabbage cluster caterpillar, cabbage white butterfly, cabbage centre grub; are all controllable with a range of chemicals, and therefore are not major issues to be addressed even though their control is necessary to maintain crop quality and marketable yield.

WEEDS

No weeds were reported as a high priority for new registrations or permits.

Normally, weeds are easily controlled in sweet corn crops by combining herbicides and cultivation, with options including crop rotation and efficient ground preparation. It is important to manage weed populations as these can harbour pests and diseases. Inter-row cultivation may be necessary within the first month of planting to break the soil crust, and later can be combined with fertiliser side-dressing and hilling-up. Cultivation needs to be shallow, as sweet corn roots are near the surface and could be damaged.

2. The Australian sweet corn industry

The Australian sweet corn industry is a well established and resourceful horticultural industry. Consumption of sweet corn has risen in recent years. It was Australia's 10th largest vegetable crop in 2010 (Ausveg 2011).

Sweet corn is grown across Australia with the main growing regions being:

- Bowen / Burdekin (Qld)
- Bundaberg (Qld)
- South east Qld
- Sydney Basin (NSW)
- Riverina (NSW)
- Murray Valley (NSW, Vic, SA)
- Gippsland (Vic)
- Perth Metro outer areas (WA)

NSW (65%) and Qld (25%) produce more than 90% of the national sweet corn production (Ausveg 2011).

In 2008/09 (for fresh and processing), there were 218 growers who planted 3,494 ha and produced 51,609 tonnes, with a gross value of $55.65 million and a farm gate value of $46.85 million. It is estimated that in 2009/10 that sweet corn production was 66,700 tonnes.

Due to Australia's varying weather conditions and the introduction of different varieties of sweet corn, especially 'super sweet' varieties, the Australian industry is now able to supply fresh sweet corn throughout the year.

3. Introduction

3.1 Background

Growers of some horticultural crops suffer from a lack of legal access to crop protection products (pesticides). The problem may be that whilst a relatively small crop area is valuable in an agricultural sense, it is not of sufficient size for agchem manufacturers to justify the expense of registering a product use on that crop. Alternately, the disease, pest, or weed problem may be regional or spasmodic, making agchem companies unwilling to bear the initial high cost of registering suitable pesticides. As an added complication some horticultural crops may be grown in protected cropping or hydroponic situations. These can have a significant impact on pesticide performance and residue outcomes, further increasing product development requirements and registration costs.

Growers may at times be in a situation where they face severe losses from diseases, pests and weeds if they do nothing to protect their crops, or face penalties if they use a product that is not registered or available via a permit. The sweet corn industry is very aware of the possible consequences of the use of unregistered or non-permitted pesticides. These can include: produce with unauthorised pesticide residues; rejection at both local and export market levels; placing Australian export trading arrangements in jeopardy, and; fines and penalties.

Environmental concerns, consumer demands, and public opinion are also significant influences in the marketplace related to pest management practices. Industry/IPM Practitioners must strive to implement best management practices and tools to incorporate a pest management regime where strategies work in harmony with each other to achieve the desired effects while posing the least risks.

Pesticides have always been an important tool in the production of sweet corn. They control the various diseases, insects and weeds that affect the crop and can cause severe economic loss in modern high intensity growing operations. Pesticides are utilized in seedling production, pre-plant, during plant establishment, through crop development and into crop maturity to maximise crop yield, quality and customer appeal.

From a pesticide access perspective, the APVMA classifies sweet corn as a minor crop. The crop fits within the APVMA crop group 012 Fruiting vegetables other than cucurbits.

As a consequence of the issues facing the sweet corn industry regarding pesticide access, Horticulture Australia Ltd and the vegetable industry undertook a review of the pesticide requirements in sweet corn via a Strategic Agrichemical Review Process (SARP). See Appendix 1 – the Strategic Agrichemical Review Process. The aim was to determine solutions (primarily pesticide) to current and future pest threats.

This SARP process identified diseases, insect pests and weeds of major concern to the industry. Against these threats available registered or permitted pesticides, along with non-pesticide solutions, were evaluated for overall suitability in terms of IPM, resistance, residues, withholding period, efficacy, trade, human safety and environmental issues. Where tools were unavailable or unsuitable the process aimed to identify potential future solutions.

This report is not a comprehensive assessment of all pests and control methods impacting on sweet corn production in Australia but attempts to prioritise the major problems.

3.2 Minor-use permits and registration

Sweet corn is classified as minor by the APVMA. Therefore access to minor use permits can be relatively straight forward as long as a reasonable justification is provided. Possible justification for future permit applications could be based on:

- New disease, insect or weed identified as a cropping issue
- No pesticide available
- Current pesticides no longer work – resistance
- Current pesticides limiting trade
- IPM, environmental or operator issues
- Loss of pesticides due to removal from market
- New, effective pesticide registered in another crop
- Alternate pesticide has overseas registration or minor use permit

With each of these options, sound, scientific argument is required to justify any new registrations or permit applications.

Another option for the industry is for manufacturers to register new pesticides uses in the crop.

3.3 Methods

The SARP was conducted in New South Wales, Queensland, Victoria and Western Australia as part of combined vegetable meetings in 2008, 2010 and 2011. The meeting included leading growers, consultants, government agencies, agchem companies and agricultural reseller staff.

- Participants were given a comprehensive list of most major pests of sweet corn and asked to prioritise them into high, moderate and low categories.
- Participants were then asked to list the main pesticides and or other control agents used for each pest.
- Mostly pesticide trade names were used and the list provided was certainly not comprehensive but a starting point for further assessment.
- Pesticides that are under review by the Australian Pesticides and Veterinary Medicines Authority (AVPMA) were listed.
- Information was collated onto Excel spreadsheets for diseases, insects and weeds.
- The information was circulated to participants for any further comments to ensure the accuracy of the information.
- Each alternative pesticide was assessed for:
    - IPM compatibility
    - Improved scope for resistance management
    - Sound biological profile
    - Residue and trade acceptance domestically and for export

Final selections of proposed new pesticides for the industry to pursue were listed.

3.4 Results

Results and discussions are presented in the body of this document.

4. Pests and diseases of sweet corn

4.1 Diseases of sweet corn

Common name	Scientific name
HIGH PRIORITY	
Java downy mildew	*Peronosclerospora maydis*
Turcicum leaf blight	*Exserohilum turcicum*
MODERATE PRIORITY	
Boil smut	*Ustilago zeae*
Damping off	*Pythium* spp., *Fusarium* spp.
Fusarium cob rot	*Fusarium* spp.
Head smut	*Sporisorium reilianum*
Johnson grass mosaic virus	
Wallaby ear	(a leafhopper (*Cicadulina bimaculata*) induced phytotoxemia)
LOW PRIORITY	
Bacterial leaf streak	*Xanthomonas campestris*
Charcoal rot	*Macrophomina phaseolina*
Common rust	*Puccinia sorghi*
Southern leaf blight	*Bipolaris maydis*
Biosecurity risk	
None listed	

Opinion on the priority of diseases can vary across the industry. As examples:

- **Java downy mildew** is not a disease found in Victoria.
- **Common rust** and **southern leaf blight** may be considered as moderate priorities in Victoria as seasonal and varietal issues. There are no registrations or permits for these diseases in Sweet corn.
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4.1.1 High priority diseases

Java downy mildew (*Peronosclerospora maydis*)

Java downy mildew is a serious concern to corn growers. Symptom expression is greatly affected by plant age, and environment. Usually, there is chlorotic striping or partial symptoms in leaves and leaf sheaths, along with dwarfing. Downy mildew becomes conspicuous after development of a downy growth on or under leaf surfaces. This condition is the result of conidia formation, which commonly occurs in the early morning.

The diseases are most prevalent in warm, humid regions.

Java downy mildew is considered a major-moderate problem especially in coastal regions of NSW and Qld. The disease can cause significant plant losses.

- Fungicides **registered** for the control of Java downy mildew in sweet corn:

    - Metalaxyl (various products) – Group 4 systemic seed treatment fungicide.
        - Commonly used as a seed treatment. All seed lots used in conventional production systems in Eastern Victoria are treated with some form of fungicide.
        - Very effective in protecting crops during early development phase.
        - Does not provide season long control.
        - Minimal impact on all beneficial insects.
        - Growers in Qld would like in-crop control options.

- No fungicides are listed for Java downy mildew control in sweet corn via **permit**.

- **Potential** fungicides for Java downy mildew control in sweet corn.

A range of fungicides are registered in other vegetable crops for control of downy mildew. These include mancozeb, metiram and phosphorous acid. Relevant MRLs for these are either in place or not required.

Additionally there are some new fungicides being assessed by the APVMA for first registrations that could be considered. Residue and efficacy data would be required.

- Fluopicolide is a new Bayer active in the FRAC group 43. This would be a novel group in Australia. It is a systemic fungicide affecting oomycetes. Bayer CropScience has applied for approval of the active in Australia but registration of a registered product will take some time. There is overseas registration on leafy vegetables / Peronospora farinose. It would be sensible to approach Bayer to discuss development opportunities.

- Cyazofamid (likely to be called RANMAN^?, new ISK/FMC Fungicide) – FRAC code 21 – contact and residual fungicide
    - Application for registration with the APVMA, for potatoes, brassicas and possibly brassica leafy
    - Inhibits oomycetes fungal development

  Resistance management tool
    - The registrant could be approached for interest in developing the product on minor crops

- Ametoctradin + dimethomorph (ZAMPRO^) – FRAC code 21+ Group 40 – contact and residual fungicide
    - Overseas work on downy mildew / bulb vegetables, brassica vegetables, fruiting vegetables, leafy vegetables, celery and hops has been reported.
    - BASF could be approached for interest in developing the product on minor crops

Turcicum leaf blight (*Exserohilum turcicum*)

Turcicum leaf blight first develops on the lower leaves of the plant as long grey-green spots and lesions. The spots and lesions then develop into long yellow-brown lesions which are covered in spores.
The spores can be spread by wind and rain are germination is favoured by warm, wet weather. The disease also survives on crop residues.

Also known as northern corn leaf blight.

Turcicum leaf blight is considered a major disease in most areas, especially in NSW and Qld. It is a minor disease in other areas. When the disease occurs it can cause significant crop losses.

- Fungicides **registered** for the control of Turcicum leaf blight in sweet corn are:

    - Chlorothalonil (various) – Group M5 protectant fungicide
        - Occasionally used.
        - It is very effective, especially in NSW when disease pressure is low. Not very effective under high disease pressure.
        - This treatment is moderately disruptive to beneficial insects in IPM situations.
        - Growers require a more effective fungicide.

- Fungicides listed for control of Turcicum leaf blight control in sweet corn via **permits**:

    - Propiconazole (various) (PER13116, expires Mar 2016) Group 3 protectant and curative fungicide
        - Commonly used.
        - Used as a protectant / curative fungicide.
        - It is very effective, especially in NSW when high disease pressure.
        - Growers expressed concern that with a heavy reliance that resistance may develop.
        - No manufacturer is interested in registering use.
        - Minimal impact on all beneficial insects.

- **Potential** fungicides for control of Turcicum leaf blight control in sweet corn:
    - Mancozeb has been suggested as a potential control option for Turcicum leaf blight.

4.1.2 Fungicide gaps and potential solutions

- Growers rely significantly on fungicide treated seed but also require in-crop solutions.
- Growers did not comment on the ability of fungicides already approved for use on other diseases in sweet corn to control Turcicum leaf blight or Java downy mildew.
- It would be helpful if products registered for the control of diseases in the major fruiting vegetables could also be registered of permitted for sweet corn, in particular as MRLs are often in place for the crop groups
- Growers would like new, particularly soft chemistry, to be considered for sweet corn

4.1.3 Non-chemical options

With limited chemical control options growers are largely dependent on management techniques, including:

- Choosing cultivars which are resistant/tolerant to disease.
- Ensuring weed populations are kept in check and monitored for insects such as aphids which can cause infection.
- Timing planting to avoid conditions that favout disease
- Crop rotations

4.1.4 Currently available fungicides

Disease Name	Active ingredient	WHP, days	Chemical group
Bean rust	Sulphur	NR	M2
Early blight/Target spot/leaf spot (*Alternaria solani*)	Penthiopyrad (FONTELIS^)	NR	7
Grey mould	Penthiopyrad (FONTELIS^)	NR	7
Java downy mildew	Metalaxyl	NR	4
Powdery mildew	Penthiopyrad (FONTELIS^),	NR	7
	Sulphur	NR	M2

Disease Name	Active ingredient	WHP, days	Chemical group
Pythium root rot	Fludioxonil + metalaxyl-M	NR	12+4
Root rot	Fludioxonil + metalaxyl-M	NR	12+4
Seed decay	Carboxin + thiram	NR	7+M3
Seedling blight/rot	Carboxin + thiram	NR	7+M3
Soil borne diseases incl Fusarium, Verticillium wilts, Rhizoctonia, Pythium	1,3-dichloropropene + chloropicrin	NR	-
Turcicum leaf blight	Chlorothalonil	1	M5
	Propiconazole (PER13116, expires Mar 2016)	28 (G,H)	3

4.2 Insects of sweet corn

Common name	Scientific name
HIGH PRIORITY	
Armyworm	*Spodoptera* spp.
Helioverpa	*Helicoverpa* spp.
MODERATE PRIORITY	
African Black Beetle	*Heteronychus arator*
Corn aphid	*Rhopalosiphum maidis*
Green vegetable bug	*Nezara viridula*
Rutherglen bug	*Nysius vinitor*
Thrips	*Thysanoptera*
Wireworm	*Elateridae*
LOW PRIORITY	
Beetles	*Coleoptera*
Crickets	*Teleogryllus* spp.
Cutworms	*Agrotis* spp.
Grasshoppers	*Orthoptera*
Leafhoppers - including Jassids	*Cicadellidae*
Sorghum head caterpillar	*Cryptoblabes adoceta*
Two-spotted mite	*Tetranychus urticae*
Biosecurity risk	
None listed	

4.2.1 High priority insects

Armyworms (*Spodoptera)*

In northern Qld there is an armyworm species, Dayfeeding armyworm (*Spodoptera exempta*) that can cause significant damage to sweet corn by eating the lower leaves of plants. These outbreaks occur in seasons following drought.

Control is required to minimise damage and plant loss.
Other armyworm species of some significance are Common armyworm (*Mythimna convecta*) and Southern armyworm (*Persectania ewingii*).

Armyworms are considered a high-moderate problem for the sweet corn industry in some regions.
- Armyworms are mainly a problem to seedlings and young plants.
- Common insecticides used are all old chemistry.
- Growers require new soft chemistry.

- Insecticides **registered** for the control of armyworms in sweet corn are:
    - Bacillus Thuringiensis (Bt) (various) - Group 11C contact insecticide
        - Bt is commonly used.
        - Very effective on small grubs, but needs regular reapplication.
        - Minimal impact on all beneficial insects.
    - Cypermethrin (various) Group 3A contact and ingestion insecticide
        - Occasionally used in some regions to get back in control when populations are high.
        - Considered very effective. Controls most lepidoptera pests.
        - This treatment is moderately to highly disruptive to beneficial insects in IPM situations. Can lead to other pest problems - mites and aphids.
    - Methomyl (various) - Group 1A contact and ingestion insecticide
        - Occasionally used in some regions.
        - Considered very effective.
        - Very effective on a range of pests, including thrips.
        - This treatment is moderately to highly disruptive to beneficial insects in IPM situations
        - Methomyl is under review by APVMA.

- No insecticides are listed for control of armyworms in sweet corn via permits.

Helicoverpa (*Helicoverpa armigera* and *Helicoverpa punctigera*)

Heliothis is also known as Corn earworm or Cotton bollworm (*H. armigera*) and Native budworm (*H. punctigera*). This caterpillar varies greatly in appearance. They can reach lengths of 50 mm. It is generally initially pale green, sometimes with black dots, and a pattern of thin dark lines running along the body, the lines being darker around the second and third segments.
Later the dark lines become less conspicuous, and the black spots develop red areas around them. There is a lot of variation in colour in the species. Some have white spots instead of black. Helicoverpa species feed prolifically on leaves and are capable of causing large amounts of damage.

- Helicoverpa are considered a high priority in all areas in terms of damage. However as there are many control options available they are not currently a high priority for action on new chemistry if IPM is utilised to keep resistance at bay.
    - Soft options are now available
    - Insecticide resistance especially in *Helicoverpa armigera,* has made this species a particularly difficult pest when insecticides are totally relied upon for control.

- Insecticides **registered** for Helicoverpa control in sweet corn are:
    - Various synthetic pyrethroids – alpha-cypermethrin, cypermethrin, deltamethrin, esfenvalerate, permethrin) - Group 3 contact/ingestion insecticide
        - Occasionally used in some regions to get back in control when populations are high.
        - Considered very effective. Controls most lepidoptera pests.
        - This treatment is moderately to highly disruptive to beneficial insects in IPM situations. Can lead to other pest problems - mites and aphids.
        - Growers expressed concern that with regular use that resistance has developed in some regions and times of year.

    - *Bacillus thuringiensis kurstaki* (Btk) (various) - Group 11C contact insecticide
        - Btk is commonly used.
        - Very effective on small grubs, but needs regular reapplication.
        - Minimal impact on all beneficial insects.

    - Chlorantraniliprole (various, including CORAGEN^) - Group 28 contact and ingestion insecticide
    - Chlorantraniliprole + thiamethoxam (DURIVO^) - Group 28 +4A contact and ingestion
        - Very effective.
        - Soft on beneficial insects.
        - Controls all lepidopteron insects.

    - Diazinon (various) – Group 1B contact and ingestion insecticide
        - Occasionally used in some regions.
        - Considered very effective.
        - This treatment is moderately to highly disruptive to beneficial insects in IPM situations.

    - Emamectin (various) – Group 6 contact and ingestion insecticide
        - Very effective.
        - Widely used as part of resistance management programs in Victoria.
        - Moderate impact on some beneficial insect species and soft on others.
        - Controls all lepidopteron insects.

    - Flubendiamide (BELT^) – Group 28 contact and ingestion insecticide
        - Commonly used in some regions up to twice per crop.
        - Controls all lepidoptera.
        - Very effective.
        - IPM compatible - low impact on beneficial insects and mites.

    - Helicoverpa NPV (various) – biological insecticide
        - Commonly used.
        - Very effective on small grubs.
        - Minimal impact on all beneficial insects.

    - Methomyl (various) - Group 1A contact and ingestion insecticide
        - Occasionally used in some regions.
        - Considered very effective.
        - Very effective on a range of pests, including thrips.
        - This treatment is moderately to highly disruptive to beneficial insects in IPM situations. Methomyl is under review by APVMA.

    - Spinetoram (SUCCESS NEO^) - Group 5A contact and ingestion insecticide
        - Very effective and also has activity against thrips.
        - Soft on most beneficials (moderate impact on parasitic wasp species).
        - Controls all lepidopteron insects.

    - Thiodicarb (various) Group 1A contact/ingestion insecticide:
        - Not used.
        - This treatment is moderately to highly disruptive to beneficial insects in IPM situations
        - Resistance to some insecticides is an important issue. Growers are trying to manage resistance with the selective use of selective insecticides and beneficial insects.

- No insecticides are available for the control of Heliothis in sweet corn via permits.

4.2.2 Summary

High Priority Insects and control options

Although there are registrations and permits for a range of pests, there are no chemicals permitted specifically for some lower priority uses. As an example, African black beetle was determined to be a moderate priority in the SARP process but can at times be a major priority in Victoria, where crop losses of 90% have been noted. Growers must rely on control by other chemicals already being used in the crop. This can be difficult when the management strategy is not targeted to the problem.

A range of pests, including: Helicoverpa, cabbage aphid, diamondback moth, green peach aphid, loopers, cabbage cluster caterpillar, cabbage white butterfly, cabbage centre grub; are all controllable with a range of chemicals, and therefore are not major issues to be addressed even though their control is necessary to maintain crop quality and marketable yield.

Disease	Control option
Armyworms (*Spodoptera*)	**Currently registered insecticides** - Bacillus Thuringiensis (Bt) (various) - Group 11C contact insecticide - Cypermethrin (various) Group 3A contact and ingestion insecticide - Methomyl (various) - Group 1A contact and ingestion insecticide **Currently permitted insecticides** None **Insecticide Gaps** New, soft chemistry **Potential insecticide solutions:** None identified, although it is expected that armyworm would be controlled by general Lepidoptera control insecticides. **Non-chemical options** IPM strategies
Helicoverpa (*Helicoverpa* spp.)	**Currently registered insecticides** - Various synthetic pyrethroids – alpha-cypermethrin, cypermethrin, deltamethrin, esfenvalerate, permethrin) - Group 3 contact/ingestion insecticide - *Bacillus thuringiensis kurstaki* (Btk) (various) - Group 11C contact insecticide - Chlorantraniliprole (various, including CORAGEN^) - Group 28 contact and ingestion insecticide - Chlorantraniliprole + thiamethoxam (DURIVO^) - Group 28 +4A contact and ingestion - Diazinon (various) – Group 1B contact and ingestion insecticide - Emamectin (various) – Group 6 contact and ingestion insecticide - Flubendiamide (BELT^) – Group 28 contact and ingestion insecticide - Helicoverpa NPV (various) – biological insecticide - Methomyl (various) - Group 1A contact and ingestion insecticide - Spinetoram (SUCCESS NEO^) - Group 5A contact and ingestion insecticide - Thiodicarb (various) Group 1A contact/ingestion insecticide **Currently permitted insecticides** None **Insecticide Gaps** None **Potential insecticide solutions:** None identified **Non-chemical options** IPM strategies – required to manage resistance.

Currently available insecticides

Insect Name	Active Ingredient	WHP	Chemical group
Ants	Pyrethrins+Piperonyl Butoxide	1	3A
Aphids	Dimethoate	7	1B
	Paraffinic Oil, Petroleum Oil	1	_
	Potassium Salts Of Fatty Acids	NR	-
	Pyrethrins+Piperonyl Butoxide	1	3A
Aphid - Corn	Spirotetramat (MOVENTO^)	7	23
Aphid – Green Peach	Chlorantraniliprole + thiamethoxam (DURIVO^)	28	4A+28
Armyworm	*Bacillus thuringiensis kurstaki*	NR	11
	Methomyl	1	1A
Armyworm – Common, Southern	Cypermethrin	7	3A
Black Sunflower Scarab	Imidacloprid	NFC	4A
Cabbage Moth	*Bacillus thuringiensis kurstaki*	NR	11
	Trichlorfon	2	1B
Cabbage White Butterfly	*Bacillus thuringiensis kurstaki*	NR	11
	Trichlorfon	2	1B
Caterpillars	Diazinon	14	1B
	Pyrethrins+Piperonyl Butoxide	1	3A
Cluster Caterpillar	Chlorantraniliprole + thiamethoxam (DURIVO^)	28	4A+28
Cricket - Black Field	Imidacloprid	NFC	4A
Crickets – Field, Mole	Chlorpyrifos	5	1B
Cutworms	Chlorpyrifos	5	1B
	Diazinon	14	1B
	Trichlorfon, Qld, NT only	2	1B
Fruit Fly	Methyl Bromide (PER11092, PER10145, Expires Oct 2014) (Fruit, Fruiting Vegetables (Not Persons Generally)	3	3A
Green Vegetable Bug	Dimethoate	7	1B
	Trichlorfon	2	1B
Helicoverpa	Alpha-Cypermethrin	7	3A
	Bacillus thuringiensis kurstaki	NR	11
	Chlorantraniliprole + thiamethoxam (DURIVO^)	28	4A+28
	Cypermethrin	7	3A
	Deltamethrin		
	Emamectin As Benzoate	3	6
	Esfenvalerate	7	3A
	Flubendiamide (BELT^)	1	2B
	Helicoverpa NPV Armigera, Zea	NA	
	Methomyl	1	1A
	Permethrin	2	3A

Insect Name	Active Ingredient	WHP	Chemical group
Helicoverpa armigera (Corn Earworm / Cotton Bollworm)	Chlorantraniliprole (CORAGEN^)	7	28
	Thiodicarb	7	1A
Helicoverpa Punctigera (Native Budworm)	Spinetoram (SUCCESS NEO^)	3	5
Jassids	Dimethoate	7	1B
Leaf hoppers	Dimethoate	7	1B
	Paraffinic Oil	1	_
	Petroleum Oil	1	_
	Pyrethrins+Piperonyl Butoxide	1	3A
Lightbrown Apple Moth	*Bacillus thuringiensis kurstaki*	NR	11
Locust - Australian Plague	Alpha-Cypermethrin/Beta-Cyfluthrin/Lambda-Cyhalothrin /	7	3A
	Carbaryl	SL	1A/1B
	Chlorpyrifos	SL	1A/1B
	Diazinon	SL	1A/1B
	Maldison	SL	1A/1B
	Cypermethrin		
Locust - Spur-Throated	Alpha-Cypermethrin/Beta-Cyfluthrin/Lambda-Cyhalothrin /	7	3A
	Cypermethrin	7	3A
Loopers	*Bacillus thuringiensis kurstaki*	NR	11
Mealybug	Potassium Salts Of Fatty Acids	NR	-
Mites	Dimethoate	7	1B
	Paraffinic Oil	1	_
	Petroleum Oil	1	_
Mite - Two Spotted Mite / Spider Mite	Abamectin (PER13657, Expires Mar 2014)	NA	6
	Sulphur	NR	_
	Potassium Salts Of Fatty Acids	NR	-
	propargite (21 day re-entry)	7	12C
Plant parasitic nematodes	1,3-dichloropropene + chloropicrin	NR	8B
Potato moth / Tomato leaf miner	Spinetoram (SUCCESS NEO^)	3	5
	Flubendiamide (BELT^)	1	2B
Rutherglen Bug	Trichlorfon	2	1B
Symphylans (garden centipedes)	1,3-dichloropropene + chloropicrin	NR	8B
Thrips	Dimethoate	7	1B
	Paraffinic Oil	1	_
	Petroleum Oil	1	_
	Potassium Salts Of Fatty Acids	NR	-
	Pyrethrins+Piperonyl Butoxide	1	3A
	Methyl Bromide (PER10145, PER11092, Expires Oct 2014)	3	8A
Thrips - Western Flower Thrips	Spinetoram (SUCCESS NEO^)	3	5

Insect Name	Active Ingredient	WHP	Chemical group
Thrips - Western Flower Thrips, Tomato	Chlorantraniliprole + thiamethoxam (DURIVO^)	28	4A+28
Vegetable weevil	Chlorpyrifos	5	1B
Vine Moth	*Bacillus thuringiensis kurstaki*	NR	11
Whiteflies	Paraffinic Oil	1	_
	Pyrethrins+Piperonyl Butoxide	1	3A
	Potassium Salts Of Fatty Acids	NR	-
Whitefly – Ggreenhouse	Emulsifiable botanica oil	NR	-
Whitefly – Greenhouse, Silverleaf	Chlorantraniliprole + thiamethoxam (DURIVO^)	28	4A+28
Wingless Cockroaches	Imidacloprid	NFC	4A
Wingless Grasshoppers	Dimethoate	7	1B
Wireworms	1,3-dichloropropene + chloropicrin	NR	8B
	Terbufos	NA	1B
Wireworms – Eastern False, Large False, Southern False, Sugarcane	Thiamethoxam	NFC	4A
Wireworm - Eastern False, Southern False, Striate False, Sugarcane	Imidacloprid	NFC	4A

Herbicide use in sweet corn

- Registered herbicides that are used in sweet corn are:
    - 2,4-D amine (various) – Group I broadleaf selective post-emergent herbicide
        - Occasionally used in-crop for broadleaf weeds.
        - Considered very effective and cheap.
        - Issues with off-target impact on surrounding crops.
        -
    - Atrazine (various) Group C broad spectrum pre-plant, pre-emergent and post-emergent herbicide.
        - Commonly used as a pre emergent in tank mix with metolachlor.
        - Considered very effective and cheap.
        - Issues with potential ground water contamination.
        - Controls many grass and broadleaf weeds.
        - Product is used both post and pre emergence, as per label.
    - Atrazine+S-metolachlore (PRIMEXTRA GOLD^)
        - used instead of tank mix.
        - Very effective.
    - Cyanazine (various) Group C broadleaf selective pre or post-emergent herbicide
        - Occasionally used in-crop for broadleaf weeds.
        - Considered very effective but narrow weeds spectrum.
    - Dimethenamid-P (various) – Group K at sowing residual herbicide
        - Occasionally used in-crop for broadleaf weeds.
        - Considered expensive.
        - Considered very effective and controls many weeds.

- EPTC (EPTAM^) Group E grass and broadleaf pre-plant herbicide
  - Growers didn't comment on use of this herbicide.

- Fluroxypyr (various) Group I broadleaf post-emergent herbicide
  - Occasionally used in-crop for broadleaf weeds.
  - Considered very effective and controls some hard to kill weeds.

- Glyphosate (various) Group M pre-plant general knockdown herbicide
  - Commonly used.
  - Works well as a pre-crop spray.

- Linuron (various) Group C general knockdown and residual herbicide
  - Occasionally used.
  - Considered very effective but narrow weeds spectrum.

- MCPA (various) – Group I broadleaf selective post-emergent herbicide.
  - Occasionally used in-crop for broadleaf weeds.
  - Considered very effective and cheap.
  - Issues with off-target impact on surrounding crops.

- Metolachlor, S-metolachlor (various) - Group K pre-plant residual herbicide
  - Commonly used as a pre emergent in tank mix with atrazine.
  - Considered very effective.
  - Controls many grass and broadleaf weeds.

- Propachlor (RAMROD^) Group H selective post-emergent herbicide
  - Occasionally used.
  - Considered very effective.
  - Controls many grass and broadleaf weeds.

- Paraquat + diquat (various) Group L pre-plant general knockdown herbicide
  - Occasionally used.
  - Works well as a pre-crop spray.

- There are no herbicides listed for control of weeds in sweet corn via permits.

Normally, weeds are easily controlled in sweet corn crops by combining herbicides and cultivation, with options including crop rotation and efficient ground preparation. It is important to manage weed populations as these can harbour pests and diseases. Inter-row cultivation may be necessary within the first month of planting to break the soil crust, and later can be combined with fertiliser side-dressing and hilling-up. Cultivation needs to be shallow, as sweet corn roots are near the surface and could be damaged.

5. References

Information

- Australasian Biological Control 2008 (http://www.goodbugs.org.au/)
- Australian Bureau of Statistics, Agricultural Commodities, 2002-03. 7121.0.
- Australian Horticultural Statistics Handbook (2003)
- Australian Pesticide and Veterinary Medicines Authority website. Website: www.apvma.gov.au
- Ausveg 'Domestic Vegetable Industry Snapshot' (2009) website: http://www.ausveg.com.au
- Ausveg 'Fresh Vegetable Exports' (2011) website: http://www.ausveg.com.au
- Codex MRL database
- Diseases of Vegetable Crops. Department of Primary Industries Queensland, 1994.
- Infopest, Department of Primary Industries and Fisheries, Queensland Government, November 2012.
- Integrated Pest Management for crops and pastures (2008) Paul Horne and Jessica Page
- IOBC Working Group - Classification of side effects to beneficial insects website: http://www.iobc-wprs.org/expert_groups/01_wg_beneficial_organisms.html
- IPM Technologies final report. Project: Pesticide effects on beneficial insects and mites in vegetables.
- IR-4 Project. Website- http://ir4.rutgers.edu/index.html
- Managing Insects and Mites in horticultural crops, QLD DPI, 1994.
- McMaugh, 'What garden pest or disease is that?' published 1989.
- Pest management strategy documents for Queensland's fruit and vegetable industries, Queensland Fruit and Vegetable growers, 2003 & 2008.
- USA Foreign Ag Service- www.mrldatabase.com

Images:

- Google images

Acronyms

APVMA ……..	Australian Pesticides and Veterinary Medicines Authority
DPI ……..	Department of Primary Industries
HAL ……..	Horticulture Australia Ltd
IPM ……..	Integrated pest management
IR-4 ……..	Interregional Research Program 4 (USA)
MRL ……..	Maximum residue limit (mg/kg or ppm)
Plant pests …..	Diseases, insects, nematodes, viruses, weeds, etc
Pesticides ……	Plant protection products (fungicide, insecticide, herbicide, nematicides, etc).
SARP …….	Strategic Agrichemical Review Process
WHP ……..	Withholding period

Australian states and territories: NSW (New South Wales), NT (Northern Territory), Qld (Queensland), SA (South Australia), Tas (Tasmania), Vic (Victoria), WA (Western Australia)

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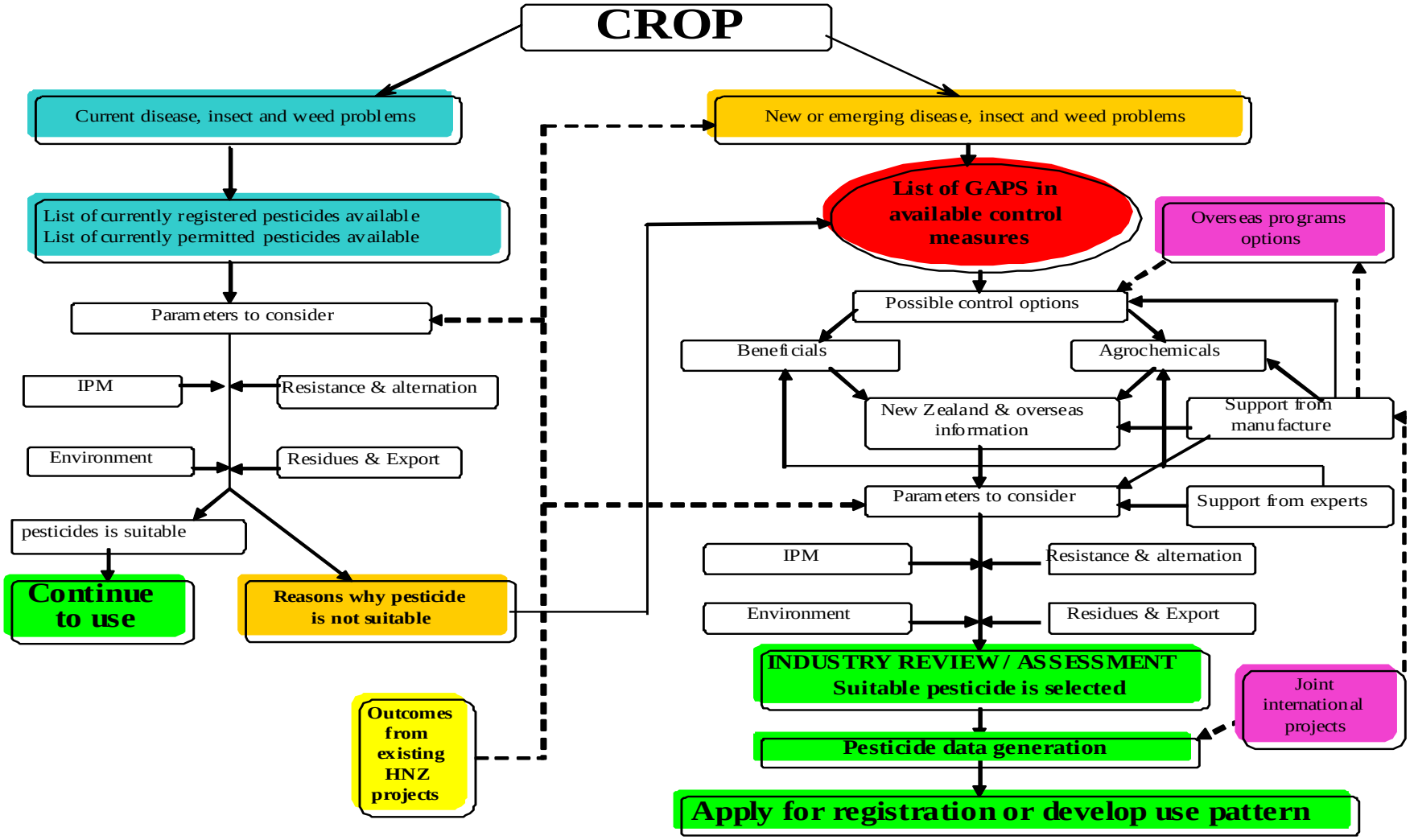
^Trademark

6. Appendices

DIAGRAM 1: The Strategic Agrichemical Review Process



Appendix 2 – currently available fungicides in sweet corn

Active ingredient	Disease Name	WHP, days	Chemical group
1,3-dichloropropene + chloropicrin	Soil borne diseases incl Fusarium, Verticillium wilts, Rhizoctonia, Pythium	NR	-
Carboxin + thiram	Seed decay, Seedling blight/rot	NR	7+M3
Chlorothalonil	Turcicum leaf blight	1	M5
Fludioxonil + metalaxyl-M	Pythium root rot, Root rot	NR	12+4
Metalaxyl	Java downy mildew	NR	4
Penthiopyrad (FONTELIS^)	Early blight/Target spot/leaf spot (*Alternaria solani*), Grey mould, Powdery mildew	NR	7
Propiconazole (PER13116, expires Mar 2016)	Turcicum leaf blight	28 (G,H)	3
Sulphur	Bean rust, Powdery mildew	NR	M2

Appendix 3 – currently available insecticides in sweet corn

Active Ingredient	Insect Name	WHP	Chemical group
1,3-dichloropropene + chloropicrin	Plant parasitic nematodes	NR	8B
	Symphylans (garden centipedes)	NR	8B
	Wireworms	NR	8B
Abamectin (PER13657, Expires Mar 2014)	Two-Spotted (Red Spider) Mite	NA	6
Alpha-Cypermethrin	*Helicoverpa Armigera* (Corn Earworm)	7	3A
	Helicoverpa Punctigera (Native Budworm)	7	3A
Alpha-Cypermethrin/Beta-Cyfluthrin/Lambda-Cyhalothrin /	Locust - Australian Plague	7	3A
Alpha-Cypermethrin/Beta-Cyfluthrin/Lambda-Cyhalothrin /	Spur-Throated Locust	7	3A
Bacillus thuringiensis kurstaki	Armyworm	NR	11
	Cabbage Moth	NR	11
	Cabbage White Butterfly	NR	11
	Helicoverpa armigera (Corn Earworm / Cotton Bollworm)	NR	11
	Helicoverpa punctigera (Native Budworm)	NR	11
	Lightbrown Apple Moth	NR	11
	Loopers	NR	11
	Vine Moth	NR	11
Carbaryl	Locust - Australian Plague	SL	1A/1B
Chlorpyrifos	Locust - Australian Plague (should also be considered for use prior to emergence to control African Black Beetle)	SL	1A/1B
Diazinon	Locust - Australian Plague	SL	1A/1B
Maldison	Locust - Australian Plague	SL	1A/1B
Chlorantraniliprole (CORAGEN^)	*Helicoverpa Armigera* (Cotton bollworm)	7	28
Chlorantraniliprole + thiamethoxam (DURIVO^)	Aphid – Green Peach	28	4A+28
	Cluster Caterpillar	28	4A+28
	Helicoverpa	28	4A+28
	Thrips - Western Flower Thrips, Tomato	28	4A+28
	Whitefly – Greenhouse, Silverleaf	28	4A+28
Chlorpyrifos	Crickets – field, mole	5	1B
	Cutworms	5	1B
	Vegetable weevil	5	1B

Active Ingredient	**Insect Name**	**WHP**	**Chemical group**
Cypermethrin	Common Armyworm		
	Helicoverpa Armigera (Corn Earworm)		
	Helicoverpa Punctigera (Native Budworm)		
	Locust - Australian Plague		
	Southern Armyworm		
	Spur-Throated Locust		
Deltamethrin	*Helicoverpa Armigera* (Corn Earworm)		
	Helicoverpa Punctigera (Native Budworm)		
Diazinon	Caterpillars	14	1B
	Cutworms	14	1B
Dimethoate	Aphids	7	1B
	Green vegetable but	7	1B
	Jassids	7	1B
	Leaf hoppers	7	1B
	Miles	7	1B
	Thrips	7	1B
	Wingless grasshoppers	7	1B
Emamectin As Benzoate	*Helicoverpa Armigera* (Corn Earworm)	3	6
	Helicoverpa Punctigera (Native Budworm)	3	6
Emulsifiable botanical oil	Whitefly – greenhouse	NR	-
Esfenvalerate	*Helicoverpa Armigera* (Corn Earworm)	7	3A
	Helicoverpa Punctigera (Native Budworm)	7	3A
Flubendiamide (BELT^)	Helicoverpa	1	2B
	Tomato leafminer	1	2B
Helicoverpa NPV Armigera	*Helicoverpa Armigera* (Corn Earworm)	NA	
	Helicoverpa Punctigera (Budworms)	NA	
	Helicoverpa Punctigera (Native Budworm)	NA	
Helicoverpa NPV Zea	*Helicoverpa Armigera* (Cotton Bollworm)	NA	
Imidacloprid	Black Sunflower Scarab	NFC	4A
	Cricket - Black Field	NFC	4A
	Eastern False Wireworm	NFC	4A
	Southern False Wireworm	NFC	4A
	Striate False Wireworm	NFC	4A
	Sugarcane Wireworm	NFC	4A
	Wingless Cockroaches	NFC	4A

Active Ingredient	**Insect Name**	**WHP**	**Chemical group**
Methomyl	Armyworms	1	1A
	Helicoverpa Armigera (Corn Earworm)	1	1A
	Helicoverpa Punctigera (Budworms)	1	1A
Methyl Bromide (PER11092, PER10145, Expires Oct 2014) (Fruit, Fruiting Vegetables (Not Persons Generally)	Fruit Fly	3	3A
	Thrips	3	8A
Paraffinic Oil	Aphids	1	_
	Leafhoppers	1	_
	Mites	1	_
	Thrips	1	_
	Whiteflies	1	_
Permethrin	*Helicoverpa Armigera* (Corn Earworm)	2	3A
	Helicoverpa Punctigera (Budworms)	2	3A
	Helicoverpa Punctigera (Native Budworm)	2	3A
Petroleum Oil	Aphids	1	_
	Leafhoppers	1	_
	Mites	1	_
	Thrips	1	_
Potassium Salts Of Fatty Acids	Aphids	NR	-
	Mealybug	NR	-
	Mite - Two Spotted Mite / Spider Mite	NR	-
	Thrips	NR	-
	Whitefly	NR	-
Propargite (21 day re-entry)	Mite - Two Spotted Mite / Spider Mite	7	12C
Pyrethrins+Piperonyl Butoxide	Ants	1	3A
	Aphids	1	3A
	Caterpillars	1	3A
	Leafhoppers	1	3A
	Thrips	1	3A
	Whiteflies	1	3A
spinetoram (SUCCESS NEO^)	Helioverpa Punctigera - Native Budworm	3	5
	Potato moth – tomato leaf miner	3	5
	Thrips - Western Flower Thrips	3	5
Spirotetramat(MOVENTO^)	Corn Aphid	7	23
	Aphid - corn	7	23
Sulphur	Mite – two spotted / red spider	NR	_
Terbufos	Wireworms	NA	1B

Active Ingredient	Insect Name	WHP	Chemical group
Thiamethoxam	Wireworms – Eastern False, Large False, Southern False, Sugarcane	NFC	4A
Thiodicarb	*Helicoverpa Armigera* (Cotton Bollworm)	7	1A
Trichlorfon	Cabbage Moth	2	1B
	Cabbage White Butterfly	2	1B
	Cutworms, Qld, NT only	2	1B
	Green Vegetable Bug	2	1B
	Rutherglen Bug	2	1B

Appendix 4 – currently available herbicides in sweet corn

Active ingredient	Chemical group
2,4-D	I
Atrazine	C
Atrazine+S-Metolachlor (PRIMEXTRA GOLD^)	C+K
Cyanazine	C
Dimethenamid-P	K
EPTC (EPTAM^)	J
Fluroxypyr	I
Glyphosate	M
Linuron	C
MCPA	I
Metolachlor	K
Paraquat	L
Paraquat + Diquat	L
Propachlor (RAMROD^)	K
S-Metolachlor	K