TECHNICAL NOTES FOR PANGAEA BOOSTER™

SUMMARY

A registered formulation for use alongside Insecticides, Fungicides, and Herbicides to help manage resistance in pest populations. It contains 927.5 g/L piperonyl butoxide (PBO).

Pangaea Booster™ can be used with all authorised plant protection products, in all edible and non-edible crops, as well as in non-crop production (stubble).

PBO inhibits Cytochrome P450 Monooxygenase Enzymes, which are responsible for pesticide detoxification within resistant pest populations.

When used as part of an effective Integrated Pest Management (IPM) programme, Pangaea Booster™ can help to reduce the number of pesticide applications and/or the pesticide dose rate required. The plant protection product is utilised sustainably and effectively.

Use the product safely. Always read the label and product information before use. Further product information, including warning phrases and symbols, is included in the product label.

VERSION CONTROL

Version	Publication Date	Main changes from previous version

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These notes are designed to support the label information on Pangaea Booster™ and advise on how to obtain the best possible pest control from the product.

INTRODUCTION

DESCRIPTION

Pangaea Booster™ is a formulation containing 927.5 g/L piperonyl butoxide (PBO). It is used in combination with Insecticides, Fungicides and Herbicides to help manage resistance in pests.

BACKGROUND

Development of Resistance

Resistance occurs primarily due to natural selection. Within an insect, pathogen, or weed population, some individuals may possess genetic traits that make them less susceptible to a given pesticide. When the pesticide is applied, susceptible individuals die, whilst resistant individuals survive and reproduce. Over successive generations, the proportion of resistant individuals increases, making the pesticide less effective. Several factors contribute to the development of resistance:

1. **Genetic Variation:** Natural diversity in populations allows resistance traits to emerge.
2. **High Reproductive Rate:** Fast-breeding organisms, such as insects and fungi, develop resistance more quickly.
3. **Frequent and Repeated Use:** Continuous application of the same pesticide selects for resistant individuals.
4. **Inadequate Dosage:** Using lower-than-recommended pesticide doses allows partially resistant individuals to survive and reproduce.
5. **Lack of Rotational Strategies:** Relying on a single pesticide without alternating chemical classes accelerates resistance development.

Metabolic Resistance

Metabolic resistance is one of the most common mechanisms by which insects, pathogens and weeds develop resistance to pesticides. It occurs when an organism breaks down or detoxifies a pesticide before it can exert its lethal effect.

Cytochrome P450 Monooxygenases (P450s):

P450 enzymes modify pesticide molecules by adding oxygen, making them more water-soluble and easier to excrete. Many insect species overproduce P450s, allowing them to rapidly detoxify pesticides. Pathogens and weeds also have this ability.

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How PBO Helps to Combat Resistance

PBO is a synergist, meaning that it is not toxic on its own but enhances the effectiveness of Insecticides, Fungicides and Herbicides on certain pest species showing resistance.

PBO works by inhibiting metabolic resistance mechanisms in two key ways:

1. **Inhibition of Cytochrome P450 Enzymes:** PBO blocks the activity of P450 enzymes, preventing the breakdown of pesticides in resistant pests. This ensures that the pesticide remains active and kills the pest population effectively.
2. **Reduction of Detoxification Capacity:** By suppressing metabolic pathways, PBO allows lower doses of pesticide to remain potent, reducing the need for higher application rates and slowing resistance development.

However, **PBO's effectiveness varies**, depending on whether P450s are the primary cause of resistance. If resistance involves other mechanisms (e.g. target site mutations), PBO may not be effective.

TARGET PESTS

Pangaea Booster™ can be used with all authorised plant protection products against resistant populations of insect, pathogen and weed pests.

COMMON UK INSECT PESTS WITH P450 ENZYME RESISTANCE

Aphid *spp*., Cabbage root fly, Tobacco/glasshouse whitefly, Spidermites, Thrips *spp*., Flea beetle, Diamondback moth.

WHY USE PANGAEA BOOSTER™?

When used as part of an effective Integrated Pest Management (IPM) programme, Pangaea Booster™ can help to reduce the number of pesticide applications and/or the pesticide dose rate required. The plant protection product is utilised sustainably and effectively.

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WHERE CAN PANGAEA BOOSTER™ BE USED?

CROPS

Pangaea Booster™ may be used on all edible and non-edible crops, as well as in non-crop production (stubble):

Crop	Plant Protection Product	Maximum Concentration (% Spray Solution)	Maximum no. of Treatments	Latest Time of Application
All Non Edible Crops	All authorised plant protection products	0.2%	Follow the statutory conditions of use of the plant protection product	Follow the statutory conditions of use of the plant protection product
All Edible Crops	All authorised plant protection products at half or less than half the authorised plant protection product rate	0.2%	Follow the statutory conditions of use of the plant protection product	Follow the statutory conditions of use of the plant protection product
Non Crop Production, All Non Edible Crops (Stubble), All Edible Crops (Stubble)	All authorised plant protection products	0.2%	Follow the statutory conditions of use of the plant protection product	Follow the statutory conditions of use of the plant protection product

In addition, this formulation may be used at a maximum concentration of 0.2% spray solution on the following crops, up to the growth stages specified, with all authorised plant protection products applied up to their full authorised rate:

Crop	Growth Stage
Almond	up to and including first fruit set
Apple and pear	up to and including fruit 5 - 10 mm
Apricot, cherry, peach and nectarine, plum	up to and including first fruit set
Table Grapes, Wine Grapes	up to and including first fruit set
Strawberry	up to and including first fruit development
Blackberry	up to and including first fruit development
Raspberry	up to and including first fruit set
Blackcurrant and redcurrant	up to and including first visible green fruitlet
Potato	up to and including tuber initiation
Carrot, Parsnip, Turnip, Swede	up to and including 9 true leaves unfolded
Red beet	up to and including six fully expanded leaves. Does not include beetroot grown for salad leaf use
Garlic, Bulb Onion, Shallot, salad onion	up to and including 9 leaves clearly visible

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Aubergine, Cucumber, Melon, Pepper and Chilli, Winter Squash and Pumpkin	up to and including first fruit set
Tomato	up to and including first fruit set on first truss
Sweetcorn	up to and including tip of tassel visible
Broccoli / calabrese	up to and including heads begin to form; width of growing tip > 1 cm2
Cauliflower	up to and including cauliflower heads begin to form; width of growing tip up to 1 cm2
Brussels sprout	up to and including lateral buds begin to develop
Cabbage	up to and including heads begin to form
Oriental cabbages	varieties forming heads: up to and including heads begin to form
Oriental cabbages	varieties not forming heads: up to and including leaf rosette has reached 30% of the diameter typical for the variety
Collard, kale	main shoot has reached 30% of the expected height typical for the variety
Lettuce	varieties forming heads: up to and including heads begin to form
Lettuce	varieties not forming heads: up to and including leaf rosette has reached 30% of the diameter typical for the variety
Rocket	up to and including 3rd true leaf unfolded
Spinach	leaf rosette has reached 30% of the expected diameter typical for the variety
Broad bean (fresh), Dwarf French bean, Runner beans, Edible podded pea	up to and including first pod set
Vining pea	up to and including flat pod (non-edible pods only)
Leek	up to and including 9 leaves clearly visible
Field bean	up to and including first pod set
Soya bean - (dry)	end of flowering: first pods visible (approx 5mm length) - BBCH 69-609
Combining pea	up to and including flat pod (non-edible pods only)
Linseed	up to and including 10% capsules formed
Oilseed rape	up to and including 10% potential pods
Borage	beginning of ripening: seed green
Soya bean	end of flowering: first pods visible (approx 5mm length) - BBCH 69-609
Cereals	up to and including GS52 (1/4 inflorescence)
Hops	up to and including cone set
Sugar beet	up to and including 6 fully expanded leaves
Forage Maize	up to and including tip of tassel visible
Fodder beet, Mangel	up to and including 6 fully expanded leaves
Beans without pods (dry)	Up to and including first pod set
Beans without pods (fresh)	Up to and including first pod set

PBO AND BENEFICIAL INSECTS

PBO alone is not an insecticide and does not have direct toxic effects on insects, including biological controls. However, it could still pose indirect risks to beneficial organisms in protected growing environments if the beneficials rely on the P450 enzymes themselves.

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PBO also has the potential to affect insect behaviour, such as reducing activity levels, feeding efficiency, or reproduction, though evidence is limited.

To minimise any negative effect on beneficials, care should be taken with regards to pesticide product selection.

A reintroduction period should be observed depending on the pesticide product being used.

PERSISTENCE

Under most conditions, PBO residues last 1-2 days on plant surfaces but can persist up to 7-14 days in protected environments.

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APPLICATION

WHEN TO USE PANGAEA BOOSTER

Pangaea Booster™ can be used alongside Insecticides, Fungicides and Herbicides, where metabolic resistance is exhibited within the pest population. The product can be used in all non-edible and edible crops, as well as in non-crop production (stubble)*.

*Please refer to the product label for detailed instructions.

APPLICATION RATE

The maximum dose is 300ml/ha.

The maximum concentration (% of spray solution) is 0.2%.

Spray Water Volume per hectare (litres)	Quantity of Pangaea Booster™ per hectare (mL)*	Quantity of Pangaea Booster™ (mL) per 100 litres *
100	200	200
500	300	60
1000	300	30
2000	300	15

*Pangaea Booster™ rate with a 300ml/ha limit applied.

SHELF LIFE

Pangaea Booster™ has a shelf life of 5 years when stored at room temperature.

COMPATIBILITIES

Pangaea Booster™ can be used with all authorised plant protection products. Not all combinations of Pangaea Booster™ and plant protection products and crops have been trialled. It is recommended that users conduct small-scale trials before widespread use with the plant protection product / crop / season combination.

DO NOT mix this adjuvant with any fertiliser products.

DO NOT spray poinsettias in full bract.

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TRIALS WORK

UK HORTICULTURAL GROWER TRIALS

UK grower trials have investigated resistant populations of Thrips, Aphid, Whitefly and Diamondback moth within a range of edible and non-edible commercial horticultural crops. Standard commercial insecticide rates were employed and Pangaea Booster™ enhanced efficacy of a wide range of plant protection products.

EUROPEAN FIELD TRIALS

Field trials in Poland and the Czech Republic evaluated Pangaea Booster™ in tank mixes targeting resistant insect populations, including:

- Pollen beetle
- Diamondback moth
- Colorado potato beetle
- Cabbage seed weevil
- Cabbage stem flea beetle

Trial parameters were as follows:

- Standard commercial insecticide rates
- 200L water/ha
- 3 replications per treatment
- 24-hour post-application evaluation

Key field trial results:

- Enhanced efficacy across all tested insecticides
- Consistent results against both primary and secondary pests
- Pangaea Booster™ improved mortality rates when added to deltamethrin, lambda-cyhalothrin, and tau-fluvalinate

GLOBAL TRIALS AND PRODUCT DISTRIBUTION

Over 300 independent laboratory and field trials utilising Pangaea Booster™ against horticultural and agricultural pest species have been conducted. The product is widely distributed throughout Europe, Asia, Australia and Africa.

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Pangaea Booster™ is a formulation containing 927.5 g/L piperonyl butoxide

Pangaea Booster™ is a trademark of Pangaea Biosciences and is marketed in the UK and Ireland by Fargro Ltd.

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