IMPROVED APPLICATION TECHNIQUES

WAYS TO HIGHER EFFICACY OF FUNGICIDES AND INSECTICIDES IN FIELD GROWN VEGETABLES

Jacob Rueegg, Reinhard Eder [1] and Viktor Anderau [2] describe application techniques which give better control of pests and diseases in a range of field grown vegetables.

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Plant protection, adjuvants, Breakthru, droplegs, Brussels sprouts, cauliflower, bush beans, potatoes, onions, leek, broccoli.

Introduction

In field grown vegetables, fungicides and insecticides are, by and large, applied with standard field booms equipped with standard flat fan nozzles or flat fan air injector nozzles typically spraying top down. Results obtained in controlling pests and diseases are often not satisfactory and farmers then tend to increase the dose or spray more often. Until recently, farmers almost invariably blamed the pesticides for inadequate control levels achieved. They argued that modern products were too "soft", had low efficacy, or that resistances to key pests and diseases had developed. Preliminary tests with water sensitive paper in bush beans indicated that by applying fungicides with a standard boom to control stem and pod rot (*Sclerotinia sclerotiorum*) may result in high deposits of active ingredient on the upper side of the leaves, but in rather low deposits on the lower parts of the stems, where the protection is most needed. Similar preliminary tests were carried out in Brussels sprouts, cabbages and onions. It was concluded that better spray methods would need to be investigated.

What are droplegs?

A dropleg is a device that consists of an aluminium tube which travels in the inter-row space and allows spray to be directed sideways and upwards to achieve better underleaf coverage lower in the crop canopy. A dropleg carries at its lower backward bent end one nozzle spraying upwards or two nozzles spraying sideways. The tube is attached to the boom with a mechanism that allows the dropleg to swing easily and fold backwards upon contact with the ground or other obstacles. Thus, the dropleg meanders through the crop without harming it. In all field work carried out over the last

For spraying onions each dropleg is fitted with a Twin-Spray-Cap carrying two green Lurmark deflector tip nozzles which produce a spray angle of 105 degrees.

Droplegs fitted with Delavan hollow cone nozzles producing a spray angle of 115 degrees travel in the interrow space through a crop of Brussels sprouts.

Field plot sprayer which carries in front on a horizontal bar conventional or air injector flat fan nozzles. Behind this bar droplegs are mounted which travel through the crop in the inter-row space. In onions each dropleg is fitted with two sidewise spraying flat fan deflector nozzles.

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Droplegs with flat fan nozzles spraying sidewise or bottom up mounted on a 12m Amazone boom operated by an organic vegetable grower in potatoes, Brussels sprouts, cauliflower, and various cabbages in Switzerland. The same boom is also fitted with flat fan nozzles spraying top down.

five years, we have never observed any noticeable crop damage. These droplegs were initially developed by Benest in the UK and successfully tested in potatoes in Scotland and England. Later Micron Sprayers Ltd in the UK bought the droplegs from Benest and is currently adding further developments to the technology. There are other brands of droplegs of which we tested a selection in potatoes. Even under high disease pressure and with intentionally reduced doses of copper fungicides droplegs gave very good control of late blight (*Phytophthora infestans*). In terms of avoiding crop damage, the Micron droplegs were superior to other more rigid types of droplegs. Micron droplegs were also tested successfully in bush beans and results have been published (see references).

Increasing the efficacy of insecticides and fungicides

Encouraged by better control levels of major diseases achieved in potatoes and bush beans with droplegs a series of field trials (most of them on farms) were carried out in Brussels sprouts, cauliflower, broccoli, onions and leek crops in Switzerland from 2002 until 2005. All these vegetables have more or less waxy leaf surfaces. When spraying commercially formulated insecticides and fungicides, it was readily observed that spray droplet behaviour on these waxy surfaces was not optimal. Part of the spray droplets would merge together to give bigger droplets which were often lost as large drops which did not wet the leaves. Spray coverage of these leaves was very uneven and inadequate. In order to spread the droplets and give better coverage of the leaf surfaces, the adjuvant Breakthru S240 (Degussa, Germany), which is a organosilicone surfactant, was included as an option in the various treatments of our field trials. A limited number of other adjuvants of the spreader type (a conventional wetting agent, Heliosol a spreader and sticker based on a pine–oil extract and a Syngenta test adjuvant similar to Breakthru) were tested as well. However, differences between these adjuvants were marginal. The important result in all these tests was that a spreading adjuvant had to be mixed in at all. Breakthru S240 was used at a maximum concentration of 0.05% or a maximum of 0.5 litres per hectare and was very well tolerated by all crops mentioned above. In Switzerland, Breakthru S240 is currently in the process of receiving an official registration as a adjuvant for selected vegetable crops.

In all our large scale on-farm trials and small scale plot trials, commercially available insecticides and fungicides were applied at the label rate. The full dose per hectare as stated on the label was applied with a conventional boom according to standard farm practices. In comparative treatments where the standard boom was combined with droplegs, usually 50% of the spray liquid was applied through the boom and 50% through the droplegs. Thus, neither the overall product dose nor the overall water volumes were changed. For the sake of further comparisons, the spray liquid was applied with and without the addition of the adjuvant Breakthru S240. The highest efficacy of the insecticides and fungicides (Table 1) was obtained by the combined use of the standard boom plus droplegs and adjuvant.

In Brussels sprouts, the combination boom plus droplegs plus adjuvant consistently gave the highest quality sprouts on the whole shoot. On farm observations also revealed that the nitrogen input in Brussels sprouts grown on organic and, to a lesser degree, on mineral soils must be carefully managed to avoid extremely dense and tall crops. In some fields, crops stood at over 130 cm in height and had a maximum leaf area index of up to 8 (= 80,000 m^2 of leaves per hectare ground

Table 1 – Increased efficacy of insecticides and fungicides in selected field vegetables through the use of improved application techniques in Switzerland. Values are based on one to four field trials per crop carried out between 2002 and 2005.

Crop	Item scored	water volumes l/ha	efficacy in % boom	boom plus adjuvant (Breakthru)	boom plus dropleg	boom plus dropleg plus adjuvant (Breakthru)
Brussels sprouts	egg deposits of white fly	400-600	56-84	68-87	61-93	**80-96**
Brussels sprouts	number of healthy roses as compared to total number of roses per plant	400-600	72-80	78	73-90	**86-96**
Broccoli	egg deposits of white fly	400-800	25	45	63	**85**
Onions	thrips larvae	300-600	14-50	31-70	52-73	**77**
Onions	lesions due to downy mildew	400-500	67	83	88	**95**
Leek	thrips larvae	800	6-57	22-73	67	**74**

surface)! Such crops, planted at 75 cm between rows and 45 cm within rows, had developed very dense leaf canopies which left no space between the plant rows. Droplegs could not travel in a vertical position through such crops, but were pushed backwards and could not spray the bottom half of the plants. Such overly tall and dense crops defied all attempts to be sprayed satisfactorily with any known technique. Machine harvesting was also slow, inefficient and produced relatively high losses of sprouts. Subsequent trials in better managed crops with heights not exceeding 100 cm and a leaf area index between 5 and 6.5 gave good dropleg performance. At harvest, sprouts on plants cut 10 cm above the ground level were almost all healthy with no blemishes from pests or diseases. Thus, very high spray efficacy, over 90%, was achieved with the standard farm spray regime of 17 to 18 sprays over a period of six months, namely about one spray every ten days. Given the superior efficacy of the combined spraying technique (boom plus droplegs plus adjuvant) the next questions which should be addressed in the future are whether spray intervals could be increased, thus lowering the overall number of sprays, and/or whether the amount of product per hectare applied could be adapted to the growing crop instead of a standard dose as stated by the label.

In onions, conventional boom plus dropleg spraying gave clearly better insecticide efficacy against thrips (Figure 1, Table 1) and the addition of the adjuvant Breakthru S240 further enhanced the efficacy of fungicides for the control of downy mildew (Figure 2, Table 1). Observations showed that because droplegs travel close to the ground between the plant rows the overall drift of spray liquid even at moderate wind speeds of below 3 metres per second was clearly reduced. Drift measurements in onions and other vegetable crops when spraying with boom and droplegs or even with droplegs alone have not been carried out so far but could demonstrate an environmental benefit of the dropleg spraying technique.

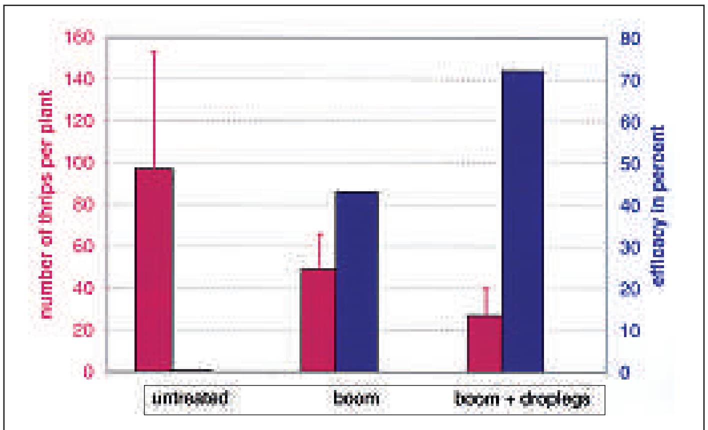

Figure 1. **Effect of the application technique on the number of thrips per plant in summer onions cv. Golden Bear on the 7 July 2003 in Switzerland and on the efficacy of two subsequent insecticide treatments. Insecticides applied were: diazinon (as Alaxon EW 600g/l) on 17 June, and dimethoate (as Perfekthion EC 400 g/l) on 4 July. The water volume was 300 litres per hectare, no adjuvant added. The crop had been sown at 45 cm between rows and 3 cm within rows. Plant height was about 50 cm, and the leaf area index was 1.1 – 1.2.**

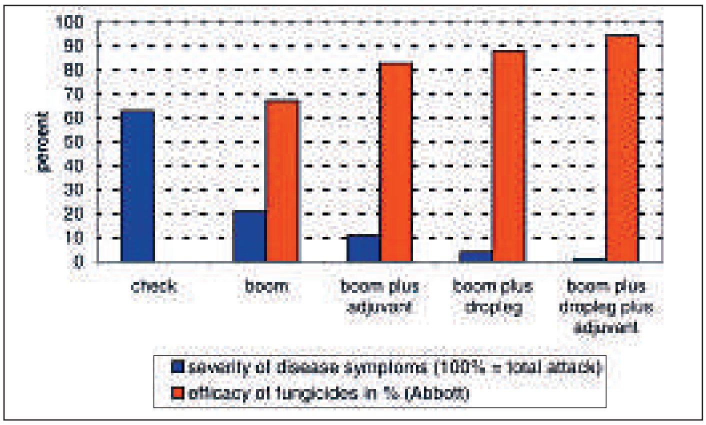

Figure 2. **Effect of the application technique on the severity of downy mildew symptoms and the efficacy of 6 fungicide treatments from May 31 until July 27 on summer onions cv. Takmark and Tamara, Lenzburg Switzerland, 4 August 2005. Fungicide applied was mancozeb 46.5% and cymoxanil 4% (as Remiltine pépite 3 kg/ha). The water volumes were 400-500 litres per hectare. The crop had been sown at 25 cm between rows and 4.3 cm within rows. The plant height was about 46 cm and the leaf area index about 1.9.**

How much spray is deposited where?

Spray deposition was assessed by adding a fluorescent tracer Helios SC500 to sprays and measuring deposits on leaves and fruits fluorometrically.

A study in cauliflower showed that the combined spraying with boom and droplegs gave a spray deposit ratio of almost 2:1 for the upper versus the bottom side of the leaves. Whereas spraying with the boom alone gave a ratio of over 5:1 (Table 2). Such differences in spray distribution can help explain the higher efficacy of plant protection products achieved with boom plus dropleg spraying. The addition of an adjuvant improves the spray distribution on the target surfaces and may enhance the efficacy of the insecticides and fungicides further (Table 1).

A tracer study in onions demonstrated that boom plus dropleg spraying as compared to boom spraying alone deposited around 40% more product on the plants with a particularly higher deposit on the bottom 10 cm of the plants which is critical for the control of thrips. The results in Figure 3 can help to explain why the combined boom plus dropleg spraying can give markedly higher control

Table 2 – Effect of the application technique on the relative amount of tracer deposited on the upper and the lower side of leaves of cauliflower planted 45 cm between rows and 43 cm within rows. Plants were 6 weeks old, had 9 to 10 leaves, an average height of 35 cm and a leaf area index of 1.0.

	relative amount of tracer deposited in %	
	upper side of leaves	bottom side of leaves
Boom only 400 L/ha plus Breakthru	79.4	20.6
Boom only 600 L/ha plus Breakthru	83.7	16.3
Boom only 600 L/ha, no Breakthru	90.5	9.5
Average of three treatments	**84.6**	**15.4**
Boom plus droplegs 400 L/ha plus Breakthru	66.5	32.5
Boom plus droplegs 600 L/ha plus Breakthru	75.3	24.7
Boom plus droplegs 600 L/ha, no Breakthru	64.5	35.6
Average of three treatments	**68.7**	**31.3**

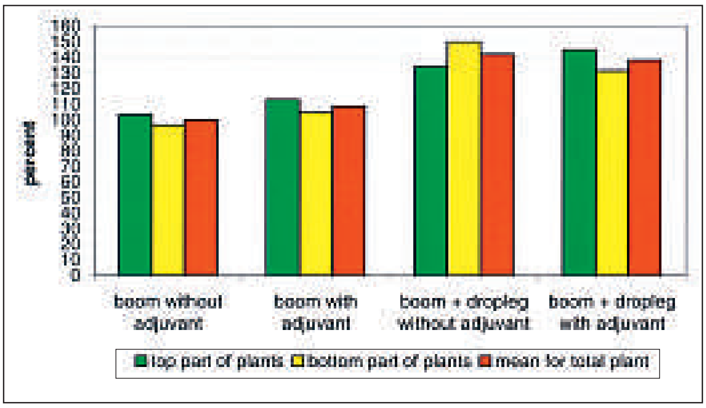

Figure 3. **Effect of the application technique on the relative amount of tracer deposited on summer onions cv. Tamara in July 2004 in Switzerland. The mean deposition for the total plant with the conventional application technique (boom without adjuvant) was set to 100%. The crop had been sown 45 cm between rows and 2.8 cm within rows and had a leaf area index of 1.5. The average plant height was 49 cm. The top part of plants consisted of leaf blades which were all cut 10 cm above ground, the bottom part of plants consisted of leaf sheaths and blades from the ground level up to 10 cm above ground.**

levels of thrips as shown in Figure 1. The addition of Breakthru has no significant effect on the amount of tracer found on the leaves, provided water volumes applied are kept below run-off levels. The adjuvant may, however, further enhance the biological product performance due to better spray distribution on the individual leaves and stems, a view which is supported by results in Table 1. High thrips populations on onions in the hot summer of 2003 resulted in partial crop failures and reduced yields. Higher control levels achieved for thrips with the combined boom plus dropleg spraying were also reflected in significantly higher onion yields and markedly higher financial returns.

For contract spraying in Brussels sprouts and potatoes this tractor carries at the rear a 15m Amazone boom fitted with conventional flat fan or air injector flat fan nozzles, and in front a 15m Amazone boom fitted with 19 droplegs 120cm long with Delavan hollow cone nozzles.

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Conclusions

In field vegetables growing in rows such as bush beans, onions, leeks, Brussels sprouts, cauliflowers and broccoli, droplegs travelling in the inter–row space can apply fungicides and insecticides in a significantly more efficient way. On critical parts of the crop such as the ground facing side of leaves or the near ground sections of the shoots, more pesticide can be deposited as compared to top down spraying from a boom alone. The combined deployment of a standard boom and droplegs distributes the spray liquid better within the crop canopy. The addition of an adjuvant improves spread of droplets on leaves with a waxy surface, thus giving better spray coverage on the individual leaf and shoot surfaces. The combined technology of boom plus droplegs plus adjuvant increased fungicide and insecticide efficacy with improved disease and insect control. On commercial farms, the dropleg spraying technique is in its early stage of introduction. In Switzerland, the first results obtained by a contract sprayer and an organic vegetable grower are encouraging. We suppose, because of economies of scale, that in the future the dropleg technique is most likely to be adopted by contract sprayers or by relatively large farms with spraying areas of several dozen hectares.

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