# STRAWBERRY GROWTH AND YIELD WITH THREE YEARS OF DRIP FUMIGATION

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The available commercial chemical alternatives to methyl bromide are 1,3-dichloropropene (1,3-D), chloropicrin (CP), and metam sodium (sodium N-methyldithiocarbamate). Relative to methyl bromide (MeBr)-CP mixture, none of these fumigants alone has the adequate broad spectrum of activity against soil-borne pathogens and weeds. Plastic mulch and drip irrigation systems are used in strawberry raised-bed culture by nearly all growers in California. Strawberry beds are usually irrigated with one or two drip tapes placed a few centimeters below the soil surface. Applications of alternative fumigants with irrigation water through drip irrigation systems may be a more effective method than shank injection in raised-bed culture. Emulsified formulations of alternative fumigants, singly or in combination, can be applied at pre-plant with water through the irrigation systems that are used to irrigate strawberries during the growing season. Application of soluble formulations to raised beds through drip irrigation systems would be economical and environmentally-friendly, reduce worker exposure, and would reduce the amount of chemicals applied. The objective of this study was to evaluate growth and yield of strawberry grown in soils fumigated with metam sodium and emulsified formulations of 1,3-D and CP applied through drip irrigation systems. Variables evaluated were amount of water used to apply the fumigants, application of combinations of fumigants, and application rate. Drip applied treatments were compared to standard MeBr-CP and Telone C35 shank injection treatments and non-fumigated plots.

## Methods

The research was conducted in two major commercial strawberry production areas in CA (Watsonville and Salinas) for three consecutive years (1997-2000). The soil in both locations had not been fumigated for the last 10 years. The soil was cultivated and beds (76 cm wide, 132 cm center-to-center) were formed (30 cm high) following standard cultural practices. Preplant treatments (Table 1) were applied to the same beds each year approximately four weeks before planting. Treatments were randomized in a complete block design with four replicates in Watsonville (10 m long beds) and three replicates at Salinas (30 m long beds). At both locations, MeBr-CP (67:33) at 365 to 425 kg $ha^{-1}$ and Telone C35 (61% 1,3-D and 35% CP) at 453 kg $ha^{-1}$ (374 L $ha^{-1}$) were shank injected at 25 to 30 cm depth with two chisels spaced 35 cm apart into soil beds that were immediately covered with embossed-green polyethylene mulch (0.03 mm thickness). Metam sodium (Vapam HL, 42%) and emulsified concentrate (EC) formulations of chloropicrin (CP EC, 96%) and Telone C35 (InLine, 58% 1,3-D and 33% CP) were applied through drip irrigation systems. Variables evaluated were application rate (label rate and 60% of that rate), application of combinations of fumigants, and amount of water used to apply the fumigants (26, 43, or 61 mm). Two drip tapes with emitters spaced 30

cm apart and emitter flow rate of 0.87 L $hr^{-1}$ at 1 bar were placed 10 cm from the bed center at a soil depth ranging from 2 to 5 cm. Fumigants were injected throughout the irrigation period into the drip irrigation system from either a nitrogen-pressurized cylinder containing the fumigant or with a positive displacement pump equipped with metering valves. At least four weeks after fumigation, plant holes were cut in the plastic mulch at 30 cm spacing and strawberry (variety Selva) was planted. The fruit were harvested at least once every week throughout the production season (early April to September) and graded into marketable and culls.

**Results**

Marketable fruit yields were significantly greater in the chemical treatments than in the untreated plots. At the Watsonville site, *V. dahliae* was a major problem that resulted in a substantial yield reduction in the untreated plots (28 to 50% relative to MeBr/CP) (Table 2). In Watsonville, the highest yield (110% relative to MeBr/CP) was in beds treated with Inline at 393 L $ha^{-1}$ applied in the high amount of water (61 mm water). Yields from beds treated with the same application rate of Inline applied in less amounts of irrigation water were generally lower than yields from the MeBr-CP treatment. Reduced rates of InLine (235 L $ha^{-1}$) or CP EC (135 L $ha^{-1}$) did not control *V. dahliea* or *Pythium* spp. in this soil. Yields from the metam sodium treated beds were lower than yields from the Inline treatments and ranged between 67 to 79% relative to MeBr-CP treatment. In 1998 and 1999, yields from the combination treatments (metam sodium plus Inline or CP applied simultaneously) were inconsistent and low relative to MeBr-CP. In 2000, the combination treatments were applied 5 days apart (Inline or CP EC followed by metam sodium). Yields from the sequential application of fumigants were greater than those produced with MeBr-CP shank injection. At the Salinas site, the greatest yields were also in beds treated with Inline. This site, however, has low population of soil-borne pathogens and yields from the nonfumigated beds were 77 to 98% relative to yields from the MeBr-PC beds.

Long-term application of Inline, CP EC, and sequential application of reduced rates of these fumigants with metam sodium to strawberry beds shows promise in controlling soil pathogens and in producing strawberry yields nearly comparable to present production with MeBr-CP. This application method can reduce costs because separate application equipment is not required. It is expected to be safer than present methods of shank injection because workers are not required to be in the field during application.

**Table 1. Fumigant application rate and method[1].**

| Chemical treatment | Treatment description |
|---|---|
| Untreated control | |
| MeBr:PC | Bed shank injected at 365-425 kg $ha^{-1}$ through two chisels |
| Telone C35 | Bed shank injected at 374 L $ha^{-1}$ through two chisels |
| InLine-$R_HW_L$ | InLine drip applied at 393 L $ha^{-1}$ in 26 mm water |
| InLine-$R_HW_M$ | InLine drip applied at 393 L $ha^{-1}$ in 43 mm water |
| InLine-$R_HW_H$ | InLine drip applied at 393 L $ha^{-1}$ in 61 mm water |
| InLine-$R_LW_M$ | InLine drip applied at 236 L $ha^{-1}$ in 43 mm water |
| InLine&MS-$R_LW_M$ | InLine at 236 L $ha^{-1}$ and Vapam at 420 L $ha^{-1}$ in 43 mm water |
| InLine&MS-$R_HW_H$ | InLine at 393 L $ha^{-1}$ and Vapam at 700 L $ha^{-1}$ in 61 mm water |
| MS-$R_HW_L$ | Vapam HL drip applied at 700 L $ha^{-1}$ in 26 mm water |
| MS-$R_HW_M$ | Vapam HL drip applied at 700 L $ha^{-1}$ in 43 mm water |
| MS-$R_HW_H$ | Vapam HL drip applied at 700 L $ha^{-1}$ in 61 mm water |
| MS-$R_LW_M$ | Vapam HL drip applied at 420 L $ha^{-1}$ in 43 mm water |
| CP&MS-$R_LW_M$ | Vapam HL at 420 L $ha^{-1}$ + CP at 130 L $ha^{-1}$ in 43 mm water |
| CP-$R_LW_M$ | Chloropicrin at 130 L $ha^{-1}$ in 43 mm water |

[1] $R_H$ and $R_L$ are high (labeled) and low (60%) application rates, respectively.
All treatments were applied to 76 cm beds (132 cm center-to-center).
Chemical rate and depth of irrigation water are presented per bed treated area (58% of gross area).

**Table 2. Strawberry Fresh Market Yield relative to Yield with Standard MeBr-CP Shank Injection (%)[1].**

| | Watsonville | | | Salinas | | |
|---|---|---|---|---|---|---|
| Chemical treatment | 1998 | 1999 | 2000[2] | 1998 | 1999 | 2000[2] |
| Untreated control | 50 | 35 | 45 | 98 | 80 | 77 |
| MeBr:PC (shank) | 100 | 100 | 100 | 100 | 100 | 100 |
| Telone C35 (shank) | 100 | 100 | 80 | 98 | 107 | 98 |
| InLine-$R_HW_L$ | 97 | 95 | 88 | 110 | 116 | 98 |
| InLine-$R_HW_M$ | 92 | 92 | 97 | 110 | 113 | 110 |
| InLine-$R_HW_H$ | 110 | 93 | 110 | 112 | 123 | 103 |
| InLine-$R_LW_M$ | 95 | 69 | 81 | 115 | 114 | 99 |
| InLine&MS-$R_LW_M$ | 73 | 68 | 111 | 103 | 112 | 101 |
| InLine&MS-$R_HW_H$ | -- | -- | -- | 109 | 89 | 107 |
| MS-$R_HW_L$ | -- | -- | -- | 99 | 102 | 85 |
| MS-$R_HW_M$ | 70 | 70 | 86 | 110 | 117 | 81 |
| MS-$R_HW_H$ | 79 | 80 | 70 | 98 | 105 | 79 |
| MS-$R_LW_M$ | 67 | 72 | 67 | 103 | 97 | 81 |
| CP&MS-$R_LW_M$ | 51 | 76 | 113 | 106 | 105 | 101 |
| CP-$R_LW_M$ | -- | 69 | 94[3] | 102 | 100 | 103[3] |

[1] Marketable yield from the MeBr:CP treatment in 1998, 1999, and 2000 in Watsonville were 62500, 56670, and 45610 kg $ha^{-1}$, respectively, and in Salinas were 26250, 17500, and 13650 kg $ha^{-1}$.

[2] In 2000, the combination treatments (InLine&MS-$R_LW_M$; InLine&MS-$R_HW_H$; and CP&MS-$R_LW_M$) were applied five days apart, and the plastic mulch was removed four weeks after fumigation.

[3] CP was applied at 130 L $ha^{-1}$ and 200 L $ha^{-1}$ in 1999 and 2000, respectively.