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# Fate and Behavior of Benthiocarb – A Herbicide in Transplanted Paddy under East-Indian Climatic Condition

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**Abstract** A two season field experiment was conducted to study the magnitude of Benthiocarb residue in transplanted paddy field soil of plough layer (6″), beyond the plough layer (12″) as well as in harvested straw, grain and husk. Transplanted paddy fields were treated once with Benthiocarb (Saturn 50 EC) @1500 g.a.i., 2500 g.a.i. and 3000 g.a.i.ha$^{-1}$. Irrespective of any season, the initial deposits (4 h after spraying) of Benthiocarb in 6″ soil layer were found in varying range of 4.01–4.22 ppm, 5.98–6.56 ppm and 7.47–8.19 ppm at recommended ($T_1$), intermediate ($T_2$) and double the recommended doses ($T_3$) respectively. In paddy field soil Benthiocarb residue dissipated 70% and 90% within 3 and 30 days respectively. Irrespective of any dose and season no residues were detected in 12″ soil layer as well as in straw, grain and husk samples at harvest.

**Keywords** Paddy · Benthiocarb · Residue · Soil

In every year, major yield losses in paddy occur due to heavy weed infestation. It occurs mainly due to sedges and broadleaves during the various stages of the plant growth. There are various herbicides to control these weeds but most of them leave toxic residues in different parts of the rice plant. Benthiocarb (S-4-Chlorobenzyl diethyl thiocarbamate) [$C_{12}H_{16}NOSCl$] is a selective herbicide of thiocarbamate group, mainly used as a pre or post emergent herbicide in the paddy field (Sharma et al. 1999). It was introduced in 1969 and reported a year later in Japan by Kumiai Chemical Industry Co. Ltd. The compound was introduced in U.S.A. by Chevron Chemical Co. in 1970 (Ishikawa et al. 1971). Recently, the herbicide has been introduced in India. Only one formulation (Saturn 50 EC) is currently available in Indian market. It is very effective against broad leave weeds in transplanted paddy field (Attalla et al. 2002). It is applied 3–4 days after transplantation of rice seedling (Tanigawa and Nishimura 1999). The compound is absorbed by the root system of the herbs, translocates to the meristem and inhibits the protein synthesis of the herbs (Matsuo and Shibayama 2002). The present investigation was conducted to determine the dissipation pattern as well as the residue level of Benthiocarb in two different soil depths [i.e. in plough layer (6″) and beyond the plough layer soil (12″)], grain, husk and straw for consecutive two seasons in West Bengal (East Indian) climatic condition when applied @ 1500 g.a.i.ha$^{-1}$ ($T_1$), 2500 g.a.i.ha$^{-1}$ ($T_2$) and 3000 g.a.i.ha$^{-1}$ ($T_3$) along with untreated control ($T_4$).

## Materials and Methods

A two season [1st season; February–May 2005 (pre monsoon), 2nd season; August–October 2005 (monsoon)], field experiment on transplanted paddy (variety IET 4786, vernacular name- Khitish) was conducted at University Research farm, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during 2005. The commercial formulation of Benthiocarb (Saturn 50 EC) was applied to paddy field 3 days after transplanting of paddy

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**Table 1** Persistence of Benthiocarb in plough layer (6″) paddy soil (1st season)

| Season | DAT | Residue in ppm [M* ± SD] (% of dissipation) | | |
|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ |
| Pre-Monsoon | 0 | 4.22 ± 0.45 | 6.56 ± 1.00 | 7.47 ± 1.23 |
| | | (–) | (–) | (–) |
| | 3 | 0.90 ± 0.09 | 1.65 ± 0.19 | 216 ± 0.69 |
| | | (78.67) | (74.85) | (71.08) |
| | 7 | 0.35 ± 0.10 | 0.84 ± 0.45 | 1.05 ± 0.09 |
| | | (91.71) | (87.19) | (85.94) |
| | 15 | 0.32 ± 0.02 | 0.77 ± 0.11 | 0.89 ± 0.33 |
| | | (92.42) | (88.26) | (88.08) |
| | 30 | 0.14 ± 0.09 | 0.35 ± 0.05 | 0.41 ± 0.05 |
| | | (96.68) | (94.66) | (94.51) |
| | 45 | 0.13 ± 0.03 | 0.29 ± 0.09 | 0.35 ± 0.20 |
| | | (96.92) | (95.58) | (95.39) |
| | 60 | 0.08 ± 0.03 | 0.19 ± 0.04 | 0.25 ± 0.06 |
| | | (98.10) | (97.10) | (96.65) |
| | Harvest | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| Regression equation | | $Y = 3.040–0.022X$ | $Y = 3.331–0.020X$ | $Y = 3.409–0.019X$ |
| Half-life (d) | | 13.68 | 15.05 | 15.84 |

seedlings. The spraying (500 L/ha) was done by a knapsack sprayer. It was applied @ 1500 g.a.i.ha$^{-1}$ (recommended dose i.e. $T_1$), 2500 g.a.i.ha$^{-1}$ (intermediate dose i.e. $T_2$), and 3000 g.a.i.ha$^{-1}$ (double the recommended dose i.e. $T_3$). Untreated control (i.e.$T_4$) was simultaneously maintained. Each treatment including control was replicated thrice in a randomized block design (RBD). The number of hills per treatment was 1000 and spacing between two successive hills was 30 × 20 cm. Replication wise soil samples (1 kg) were collected randomly from each treatment for two depths [i.e. plough layer (6″) and beyond the plough layer (12″)]. Soil samples were drawn by using a split tube augur at different time intervals [0 (4 h), 3,7,15,30,45,60 days and at harvest] after application of Benthiocarb. Grain (500 g) and straw samples (1 kg) were collected randomly from each treatment replication wise only at harvest.

The residue was extracted from soil samples (100 g) by keeping it overnight in 200 mL acetone followed by mechanical shaking for 2 h. The extract was filtrated through a buchner funnel using Whatman no.1 filter paper. The residue was re-extracted twice (2 × 50 mL) with acetone. Then the combined filtrate was concentrated in a rotary vacuum evaporator at 40°C and transferred to a 500 mL separatory funnel with addition of 150 mL water and 20 mL of saturated sodium chloride solution. Then it was partitioned thrice with ethyl acetate (100 + 50 + 50 mL) and allowed to separate the phases. The ethyl acetate layer was passed through anhydrous sodium sulphate. The combined ethyl acetate fraction was concentrated in a rotary vacuum evaporator at 40°C and volume was made up to 10 mL with distilled ethyl acetate for GC-analysis (Liu et al. 1991).

Grain sample (100 gm) was extracted with 300 mL acetone by 6 h reflux in the soxhlet apparatus. The acetone extract was concentrated in the rotary vacuum evaporator at 40°C. Then similar procedure was followed as mentioned for soil.

Straw sample (25 gm) was chopped in small pieces and packed in a soxhlet apparatus. Then 300 mL acetone was added to it and refluxed for 6 h. The acetone extract was concentrated in the rotary vacuum evaporator at 40°C. Then the similar procedure was followed as mentioned for soil.

Final analysis of Benthiocarb residues in paddy field soil, grain and straw were done by GC (Agilent Technologies 6890N Network GC system) with nitrogen phosphorous detector (NPD) coupled with Chemito 5000 data processor. The HP−5 capillary column (30 m × 0.32 mm i.d.) of 0.25 μm film thickness was used. The temperatures were: Oven 210°C, Injector 230°C, Detector 300°C. Flow rate of the carrier gas (nitrogen), hydrogen and air were 2, 4 and 60 mL min$^{-1}$ respectively. The retention time, limit of detection (LOD) and limit of quantification (LOQ) were 4.30 min, 0.01 μg g$^{-1}$ and 0.05 μg g$^{-1}$ respectively.

The average recovery of Benthiocarb in paddy soil, grain and straw spiked at 0.25, 1.0, 5.0 ppm levels were in the ranges 82.3–86.7%

**Table 2** Persistence of Benthiocarb in plough layer (6″) paddy soil (2nd season)

| Season | DAT | Residue in ppm [M* ± SD] (% of dissipation) | | |
|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ |
| Monsoon | 0 | 4.01 ± 0.80 | 5.98 ± 1.73 | 8.19 ± 1.54 |
| | | (–) | (–) | (–) |
| | 3 | 0.59 ± 0.23 | 1.07 ± 0.69 | 1.66 ± 0.34 |
| | | (85.29) | (82.11) | (79.73) |
| | 7 | 0.25 ± 0.12 | 0.60 ± 0.16 | 1.11 ± 0.45 |
| | | (93.77) | (89.97) | (86.45) |
| | 15 | 0.22 ± 0.10 | 0.45 ± 0.22 | 1.03 ± 0.43 |
| | | (94.51) | (92.47) | (87.42) |
| | 30 | 0.10 ± 0.10 | 0.36 ± 0.18 | 0.82 ± 0.47 |
| | | (97.51) | (93.98) | (89.99) |
| | 45 | BDL | BDL | 0.18 ± 0.06 |
| | | (–) | (–) | (97.80) |
| | 60 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | Harvest | BDL | BDL | BDL |
| Regression equation | | $Y = 3.080–0.042X$ | $Y = 3.296–0.031X$ | $Y = 3.503–0.027X$ |
| Half-life (d) | | 7.17 | 9.71 | 11.15 |

**Table 3** Persistence of Benthiocarb in beyond plough layer (12″) paddy soil (1st season)

| Season | DAT | Residue in ppm [M* ± SD] (% of dissipation) | | |
|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ |
| Pre-monsoon | 0 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 3 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 7 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 15 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 30 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 45 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 60 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | Harvest | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| Regression equation | | – | – | – |

**Table 4** Persistence of Benthiocarb in beyond plough layer (12″) paddy soil (2nd season)

| Season | DAT | Residue in ppm [M* ± SD] (% of dissipation) | | |
|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ |
| Monsoon | 0 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 3 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 7 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 15 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 30 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 45 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | 60 | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| | Harvest | BDL | BDL | BDL |
| | | (–) | (–) | (–) |
| Regression equation | | – | – | – |

## Results and Discussion

The residue data of Benthiocarb (Saturn 50 EC), regression equation and half-life for consecutive two seasons at different days interval are represented in the Tables (1–5). Interestingly, the result showed that Benthiocarb residues in paddy field soil declined progressively with time irrespective of any dose and season. The initial deposits (4 h after spraying) of Benthiocarb in 6″ soil layer were found to be in the range of 4.01–4.22 ppm at the recommended

**Table 5** Harvest residue of Benthiocarb in paddy grain and straw (1st season & 2nd season)

| Days after application | Substrates | Treatment | Residues in ppm (μg/g) (M* ± SD) [Dissipation (%)] | |
|---|---|---|---|---|
| | | | Season-I | Season-II |
| Harvest | Grain | $T_1$ (1500 g.a.i./ha) | BDL [–] | BDL [–] |
| | Straw | | BDL [–] | BDL [–] |
| Harvest | Grain | $T_2$ (2500 g.a.i./ha) | BDL [–] | BDL [–] |
| | Straw | | BDL [–] | BDL [–] |
| Harvest | Grain | $T_3$ (3000 g.a.i./ha) | BDL [–] | BDL [–] |
| | Straw | | BDL [–] | BDL [–] |

BDL = Below detectable limit (<0.01 ppm)

M* = Mean of three replicate

dose ($T_1$), 5.98–6.56 ppm at intermediate dose ($T_2$) and 7.47–8.19 ppm at double the recommended dose ($T_3$) irrespective of any season. The residue was found below the detectable limit in the untreated control ($T_4$) as well as in 12″ soil layer with time irrespective of any dose and season. It was also observed from the study that the dissipation rate was very fast. About 70% residues were dissipated in paddy field soil within 3 days after application irrespective of any dose and season (Tables 1, 2). No residue was detected in grain as well as in straw samples at harvest irrespective of any dose and season. It could be evident from the tables that more than 90% residue of Benthiocarb was diminished in paddy field soil of plough layer on and from 30 days after application in all the doses irrespective of any season. The residues were found below the detectable limit in paddy field soil of plough layer at harvest. From the tables it is clear that in paddy field soil no leaching or percolation loss of the herbicide was occurred from 6″ to 12″ soil layer. As the residues were found below the detectable limit in all harvest samples, therefore it might be stated that Benthiocarb may not cause any residual toxicity problem in paddy which is also befitting with the harvest schedule of paddy cultivation of eastern region of our country.

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