The distribution pattern of the ^{14}C in the organs, tissues milk and urine of a lactating goat dosed orally with [^{14}C]2,4-D showed that the kidney (which contained 0.45% of the dose) is the main target organ. Lower proportions were found in the liver (0.07 %), milk (0.06%), fat (0.03 %) and muscle (0.01 %), whereas the total ^{14}C in the urine was 99.4 % (97.9% identified as 2,4-D). The metabolites found at lower levels were 2- or 4-chlorophenoxyacetic acid (2- or 4-CPAA) and 2,4-dichlorophenol (2,4-DCP).

In hens dosed orally with [^{14}C]2,4-D, about 90% of the dose was recovered from the excreta. The edible tissues and eggs each contained <0.1% of the total dose.

Bluegill sunfish were exposed to 11 mg/l [^{14}C]2,4-D in their water under static conditions for four consecutive days. The total ^{14}C (as 2,4-D) in the day-4 viscera (inedible) and fillet (edible) represented 1.9 and 0.41 mg/kg respectively. 2,4-D (80% of the ^{14}C, 0.33 mg/kg) and 2,4-DCP (7.9% of the total ^{14}C, 0.03 mg/kg) were present in the edible portion.

Information on the metabolism of 2,4-D in plants was provided for apples, lemons, potatoes and wheat.

After application of the 2-ethylhexyl ester to a potato crop at a rate of 0.35 kg acid equivalent per hectare (ae/ha), the residues in the tubers were 0.24 mg/kg 2,4-D (42% of the total ^{14}C), 0.15 mg/kg 4-CPAA (26% of the total ^{14}C) and 0.09 mg/kg 4-hydroxy-2,5-D (15.5% of the total ^{14}C).

In apples after the spray application of [^{14}C]2,4-D to the turf beneath the canopy of a dwarf apple tree according to label instructions, the residues were too low to be identified (total ^{14}C 0.009 mg/kg as 2,4-D).

In the forage and straw of wheat treated with 2,4-D-EME 74 and 70% of the total ^{14}C was recovered as free or conjugated 2,4-D. The rest consisted of a large number of distinct metabolites, of which 4-hydroxy-2,5-D was the major compound (8% of the total ^{14}C). In wheat grain about half the total ^{14}C was associated with natural products (protein, starch and cellulose). The remainder consisted mainly of unidentified polar and unextractable compounds. 2,4-D accounted for 6% of the total ^{14}C and was the only component identified.

[^{14}C]2,4-D IPE applied to lemons post-harvest resulted in residues of 2.4 mg/kg as 2,4-D. The fruits were stored at 5-6°C up to 16 weeks. Most of the total ^{14}C was found in the peel, with very small amounts in the pulp and juice. Lemon peel at 20 weeks contained 93.5% of the total ^{14}C (2.1 mg/kg). These residues were mainly free and conjugated forms of 2,4-D (64% of the total ^{14}C, 1.5 mg/kg). Other compounds found in minor quantities were free and bound 2,4-D IPE (0.73 % of the total ^{14}C, 0.017 mg/kg), 4-hydroxy-2,3-D or 5-hydroxy-2,4-D (0.58%, 0.013 mg/kg), 4-hydroxy-2,5-D (0.44%, 0.01 mg/kg) and 2,4-DCP (0.72%, 0.016 mg/kg). The main metabolites found in the pulp and juice were also free and conjugated 2,4-D (2.9% of the total ^{14}C, 0.07 mg/kg in the pulp; 0.99% of the total ^{14}C, 0.023 mg/kg in the juice).

The degradation of 2,4-D does not lead to environmentally significant levels of degradation products in soil or water.

Under aerobic incubation conditions, 2,4-D is rapidly degraded in soil (half-life in silty clay soil 1.7 days at 25°C). The final degradation products are CO_2 and soil-bound residues, which are mostly distributed in the fulvic acid and huminic acid fractions of the soil.

Further information was received on the fate of the 2-ethylhexyl and isopropyl moieties of the 2,4-D esters and the dimethylamine and diethanolamine of the salts.

The K_{OC} values of [^{14}C]2,4-D ranged from 59 to 117, indicating a fairly high potential for 2,4-D to be leached through the tested soils (Arizona clay loam, Mississippi loam, California sandy loam, Plainfield sand), whereas the leaching potential of the degradation products 2,4-dichloroanisole (K_{OC}: 436-1442) and 2,4-dichlorophenol (K_{OC}: 368-1204) is medium to low. In contrast to that, the results of two field lysimeter studies show that 2,4-D and its degradation products are not mobile in sandy soils (pH 5.7 in the first 30 cm, 4.8-5.0 in the next soil horizons). This indicates that 2,4-D, in spite of its high potential to be leached, is not expected to be found in groundwater (owing to its rapid degradation in the soil) when the product has been used in compliance with GAP.

Terrestrial field dissipation studies with the dimethylamine salt and 2-ethylhexyl ester over a 2-year period showed similar rates of dissipation of 2,4-D when applied as either the salt or ester because both formulations are converted rapidly to the same anionic form.

Residues in rotational crops were determined in radishes, lettuce and wheat planted 30 and 139 days after the treatment of the soil with [^{14}C]2,4-D at a rate of 2.2 kg ae/ha (acid equivalent/ha). The total radioactive residues in the 30-day crops were <0.001 mg/kg in wheat forage, 0.01 mg/kg in radish roots and 0.06 mg/kg in wheat straw. No ether-soluble residues from free or conjugated 2,4-D or its metabolites were present at levels above 0.01 mg/kg after a 30-day planting interval. The ^{14}C residues observed in the rotational crops planted after both 30 and 139 days were due to incorporation into natural products.

An aerobic aquatic degradation study of [^{14}C]2,4-D was conducted at a concentration of 5 mg/l for up to 46 days. 2,4-D acid was degraded slowly at first and represented $\leq$75% of the applied dose after 25 days. The rate of degradation then increased sharply and at day 46 2,4-D represented only 0.5% of the applied radioactivity. The major product was CO_2, which accounted for 64% of the applied ^{14}C at the end of the study period. The highest levels of the other identified residues (expressed as % of applied ^{14}C) were 1.1% 2,4-dichlorophenol at day 35, 1.1% 4-chlorophenoxyacetic acid at day 14 and 1.4 % 4-chlorophenol at day 20.

2,4-D is not likely to remain long in the environment under anaerobic aquatic conditions, in which it was degraded with a half-life of 41 days.

Further information was received on the aquatic field and pond dissipation of the dimethylamine salt and its major degradation products 2,4-D, 2,4-dichlorophenol, 2,4-dichloroanisole, 4-chlorophenoxyacetic acid and 4-chlorophenol.

The current residue analytical methods are based on extraction with a basic aqueous solution before clean-up by solid phase extraction on a C18-bonded silica cartridge and solvent partitioning. After methylation and further clean-up of the ester, the 2,4-D residues are determined as 2,4-D methyl ester by GLC with an ECD. The method was validated for plant and animal commodities with recoveries above 70%. The typical limits of determination in plant materials, milk and animal tissues are 0.01- 0.05 mg/kg. For most of the supervised trials the reported LOD was 0.01 mg/kg. Residues were determined in water, soil and sediment by GLC with mass-selective detection with LODs of 0.001 mg/l in water and 0.01 mg/kg in soil and sediment.

The analytical method provided by The Netherlands is based on similar extraction and clean-up procedures but the SPE extracts are further processed by column-switched HPLC on a pre-column packed with internal surface reversed-phase (ISRP) material and a bonded C-18 analytical column with UV detection at 118 nm. The LOD was reported to be 0.02 mg/kg for meat and 0.05-0.1 mg/kg for cereals and vegetables.

Information was submitted on the stability of 2,4-D residues in various stored analytical samples. The Meeting concluded that the compound was stable for the duration of the studies (at least two years in potatoes, cherries and cranberries and for one year in the raw agricultural commodities and processed products of cereal grains, fodder and forage, oil seed, sugar cane, grapes and pears, and for seven months in citrus fruits, plums and peaches).

The nature of the 2,4-D residues in plants is adequately understood from the apple, lemon, potato and wheat metabolism studies, and the residues in animals are known from the mouse, rat, goat, poultry and fish metabolism studies.

The Meeting concluded that the definition of the residue in plants and animals should be defined as 2,4-D *per se* for compliance with MRLs and for the estimation of the dietary intake.

The value of the partition coefficient of 2,4-D at natural pH values (log P_{OW} = 0.18 and –0.83 at pH 5 and 7 respectively) indicates that the compound is not fat-soluble.

Plant metabolism studies on wheat and potatoes treated with the 2-ethylhexyl ester and on lemon treated with the isopropyl ester indicate nearly complete hydrolysis of the esters by about 10 days after treatment with 2,4-D as the terminal residue of importance. Mammalian pharmacokinetic and metabolism studies in rats and mice indicate that the 2-ethylhexyl ester is rapidly converted to 2,4-D acid and its metabolism can be considered to be equivalent to that of 2,4-D. For these reasons, the definition of the residue arising from the application of the ethylhexyl ester or other esters should be the same as that for the residue from the free acid.

Supervised residue trials on numerous crops were carried out all in the USA and evaluated against US GAP. Because no significant difference was observed between the residues left by the acid, esters and salts, the trials in which 2,4-D acid, the ethylhexyl ester and 2,4-D dimethylamine salt were applied were combined for evaluation.

Citrus fruits. 2,4-D is used as a plant growth regulator pre-harvest on grapefruit and oranges (US GAP 1 x 0.0024 kg ae/hl, PHI 7 days), and post-harvest on lemons (US GAP 1 x 0.05 kg ae/hl). The Meeting was informed that foliar spraying of grapefruit and oranges with 2,4-D is a minor use.

Two trials according to US GAP were carried out on grapefruit. Because one year passed between the first and the last application, the samples of mature fruits from 1994 and 1995 are used for evaluation. The residues in the whole fruit were <0.05 (2), 0.07 and 0.08 mg/kg. Two further trials complying with GAP on oranges both resulted in residues in the whole fruit below the LOD: <0.05 mg/kg. All the residues in rank order were <0.05 (4), 0.07 and 0.08 mg/kg. The Meeting estimated a maximum residue level of 0.1 mg/kg for grapefruit and oranges, and recommended withdrawal of the current CXL of 2 mg/kg for citrus fruit. As no residue data were submitted for the edible pulp the Meeting estimated an STMR of 0.05 mg/kg, based on the residues in the whole fruit.

Two supervised residue trials of post-harvest use on lemons were carried out in California. No decrease of the residue level during storage (0-112 days at 6-16°C) was observed (range from 0.29 to 0.61 mg/kg). The Meeting could not estimate a maximum residue level owing to the small number of trials.

Use as herbicide in orchards and vineyards

A further use of 2,4-D in fruits is for weed control with applications directed to the orchard or vineyard floor. The apple metabolism study indicates that no residues are to be expected in the fruits after application directed to the orchard floor and is supporting the interpretation of the supervised trial residue data.

Pome fruits. A number of trials on apples and pears in the USA complied with current GAP (2 x 2.2 kg ae/ha, directed application, PHI 14 days). The residues in the fruits from all the 10 trials available were below the LOD of 0.01 mg/kg at 13-15 days PHI. The Meeting estimated a maximum residue level for pome fruits of 0.01* mg/kg as being a practical limit of determination. Because the residues were below the LOD in all samples, including fruit from one trial at a fivefold rate, an STMR level of 0 was estimated.

Stone fruits. Three trials each on cherries, peaches and plums (one on fresh prunes) treated at rates up to the maximum US GAP (2 x 1.6 kg ae/ha, directed application, PHI 14 days) resulted in residues below the LODs of 0.05 mg/kg (cherries) or 0.01 mg/kg (peaches and plums) at 14 days PHI. The Meeting estimated a maximum residue level for stone fruits of 0.05* mg/kg as being a practical limit of determination. Because the residues were below the LOD in all samples including fruit from one trial at a fourfold rate an STMR level of 0 was estimated.

Berries and other small fruits. In four blueberry trials at rates of 2 x 1.6 kg ae/ha as a directed application which complies with GAP in the USA, residues up to 0.01 mg/kg were found about 30 days after the last application. The residues were <0.01 (2) and 0.01 (2) mg/kg.

In six residue trials on strawberries according to US GAP (1 x 1.7 kg ae/ha, before blossom), no residues (<0.05 mg/kg) were found 59-129 days after treatment.

Two US trials on cranberries with 3 x 4.5 kg ae/ha were reported. US GAP specifies 2 x 4.5 kg ae/ha, directed application. At a PHI of 30 days, no residues above the LOD of 0.02 mg/kg were found in samples from the first trial but up to 0.11 mg/kg in those from the second trial.

Only one trial was carried out on raspberries (1 x 1.6 + 1 x 3.1 kg ae/ha). No residues above the LOD of 0.05 mg/kg were found. No residue data were reported for blackberries.

Two residue trials were carried out on grapes according to current US GAP (1 x 1.6 kg ae/ha, directed application). No residues above the LOD of 0.05 mg/kg were found at the recommended PHI of 100 days.

All the residues from trials complying with US GAP for berries in rank order were <0.01 (2), 0.01 (2), <0.05 (9) and 0.11 mg/kg.

The Meeting estimated a maximum residue level of 0.1 mg/kg for berries and other small fruits (including grapes) and recommended withdrawal of the CXLs for blackberries, raspberries, and vaccinium berries (including bearberry).

The Meeting estimated an STMR of 0.05 mg/kg for berries except grapes, and an STMR of 0 mg/kg for grapes because of their special use pattern (100 days PHI and high phytotoxicity).

Use as herbicide on vegetables

2,4-D is directed to the ground for weed control in vegetables. Supervised trials on sweet corn, potatoes and asparagus were reported.

Sweet corn (corn-on-the-cob). Nine supervised trials at US application rates were reported. Only two of them included the recommended PHI of 21 days but the treatment in all the trials was carried out at the registered plant growth stage. The residues were at or below the LOD of 0.05 mg/kg in all samples of kernels plus cob with husks removed. The Meeting estimated a maximum residue level for sweet corn of 0.05* mg/kg as being a practical limit of determination, and an STMR of 0.05 mg/kg.

Potatoes. Eight of ten trials in the USA complied with US GAP (2 x 0.078 kg ae/ha). The treatments were carried out at the registered plant growth stage. At harvest, the residues were <0.05 (5), 0.08 (2) and 0.13 mg/kg. The Meeting confirmed the current CXL of 0.2 mg/kg and estimated an STMR of 0.05 mg/kg.

Asparagus. Four trials covering the US application rate were reported but only two included the specified PHI of 3 days (the residues were 0.1 and 3 mg/kg). Two trials are not enough to estimate a maximum residue level.

Use as herbicide on cereals

2,4-D is used world-wide for the pre- or post-emergence or pre-harvest treatment of winter and summer cereals.

Maize. After three applications of the dimethylamine salt (7 trials), 2-ethylhexyl ester (6 trials), or free acid (1 trial) totalling 3.4 kg ae/ha, the residues of 2,4-D in grain after 7 days (US GAP) or 14 days were <0.01, 0.01 (8), 0.015, 0.02 (2), 0.03 and 0.04 mg/kg (4 residues at 14 days were higher than the corresponding 7-day residues). The Meeting estimated a maximum residue level of 0.05 mg/kg to replace the current CXL (0.05* mg/kg) and an STMR of 0.01 mg/kg.

Rice. Seven of ten supervised US trials complied with GAP (1 x 1.7 kg ae/ha, PHI 60 days). The residues in the rice grain without husk in rank order were <0.01(2), 0.01 (3), 0.03 and 0.05 mg/kg. The Meeting estimated a maximum residue level of 0.1 mg/kg for husked rice to replace the current CXL of 0.05* mg/kg for rice and an STMR of 0.01 mg/kg.

Wild rice. Only one overdosed trial (4 replicates) was reported. No residues were found after treatment with 0.56 kg ae/ha at day 53 or 64. One trial is not enough to estimate a maximum residue level.

Sorghum. 2,4-D is registered in the USA for applications of 0.56 kg ae/ha of esters or 1.1 kg ae/ha of the acid or salts. In a total of ten trials in four US states the recommended rates were applied at the registered plant growth stage.

No residues above the LOD of 0.01 mg/kg were found in the grain at harvest. The Meeting estimated a maximum residue level for sorghum of 0.01* mg/kg as being a practical limit of determination to replace the current CXL of 0.05* mg/kg, and an STMR of 0.01 mg/kg.

Wheat and rye. Many field trials were carried out on wheat in the USA, 24 of them according to US GAP (1.4 + 0.56 kg ae/ha, PHI 14 days). The residues in wheat grain in rank order were 0.11 (2), 0.12, 0.13, 0.16 (2), 0.17 (4), 0.21, 0.22 (2), 0.23, 0.24 (2), 0.31, 0.34, 0.46, 0.63, 0.87, 0.94, 0.95 and 1.4 mg/kg. The Meeting agreed to extrapolate the residue data from wheat to rye because GAP is identical and estimated maximum residue levels of 2 mg/kg to replace the current CXLs of 0.5 mg/kg with STMRs of 0.22 mg/kg.

Other cereals. 2,4-D is registered world-wide for use on barley, millet, oats and triticale. Although the US GAP for barley, oats and millet is the same as for wheat the Meeting agreed that extrapolation from wheat to barley, oats and millet could be recommended because the residue could be considerably higher from the use after blossom at the dough stage.

2,4-D is registered on triticale in Australia (1 x 1.6 kg ae/ha, PHI 7 days). Many US trials on wheat complied with Australian GAP but the Meeting did not support extrapolation of the US data as the climatic conditions are different.

The Meeting agreed to recommend the withdrawal of the current CXLs for barley and oats of 0.5 mg/kg and could not estimate a maximum residue level for millet or triticale.

Sugar cane. Eight US supervised trials according to GAP with one pre-emergence and one post-emergence treatment of 2.2 kg ae/ha were reported. The residues in mature cane at PHIs of 137-214 days were <0.01 (7) and 0.02 mg/kg. The Meeting estimated a maximum residue level of 0.05 mg/kg and an STMR of 0.01 mg/kg.

Tree nuts. Ten trials each on almonds and pecans were carried out in the USA, five with directed applications of the dimethylamine salt and five with the 2-ethylhexyl ester, according to US GAP (2 x 1.6 kg ae/ha, PHI 60 days).

Two trials with directed applications on pistachio nuts were also according to US GAP (2 x 1.6 kg ae/ha, PHI 50 days).

Three trials each with the dimethylamine salt and the 2-ethylhexyl ester complied with the critical US GAP on hazelnuts, where 4 x 0.12 kg ae/hl are used as a spray to the stems of suckers with a PHI of 45 days.

The residues were <0.05 (8), 0.08 and 0.16 mg/kg in almond kernels, below the LOD of 0.05 mg/kg in all the samples of pecans and pistachio nuts and <0.05 (2), 0.05 and 0.1 mg/kg in hazelnuts. All residues in rank order were <0.05 (22), 0.05, 0.08, 0.1 and 0.16 mg/kg.

The Meeting estimated a maximum residue level for tree nuts of 0.2 mg/kg and an STMR of 0.05 mg/kg.

Soya bean seed, fodder and forage. The use of 2,4-D is registered in the USA for pre-planting applications of 1 x 0.56 kg ae/ha of esters or 1 x 1.1 kg ae/ha of free acid or salts. Twenty seven supervised trials were reported, with treatments of 0.56, 1.4 or 3.2 kg ae/ha. The residues in all samples of beans were lower than the LOD of 0.01 mg/kg. The Meeting concluded that no detectable residue is likely to occur in soya beans, and estimated a maximum residue level of 0.01* mg/kg and an STMR of 0 mg/kg.

No residues were detected in any of the 27 samples of fresh forage.

The fodder samples were analysed after air-drying forage for 1.5-7 days after cutting. No residues above the LOD of 0.01 mg/kg were found in the nine trials according to GAP. Residues up to 0.04 mg/kg were found after the treatments at higher rates.

The Meeting concluded that no detectable residue is to be expected in soya bean forage (green) or fodder, and estimated maximum residue levels of 0.01* mg/kg as a practical limit of determination. STMRs of 0 for soya bean forage (green) and 0.01 mg/kg for fodder were estimated.

Animal feedstuffs

Forage, hay or fodder of grasses. Supervised trials according to US GAP (2 x 2.2 kg ae/ha) were reported on rangeland and pasture grass used for animal feed. The Meeting was informed that a PHI of 0 days has to taken into account for the estimation of a maximum residue level for rangeland. The residues in the forage on the day of treatment in rank order were 90, 92, 135, 153, 154, 162, 169, 172, 173, 177, 182, 183, 192, 194, 198, 223, 233, 236, 241, 258, 271, 280, 285, 31, 314 and 358 mg/kg. The Meeting estimated an STMR of 193 mg/kg for grass forage.

The highest residues from each trial on hay (PHI of fresh forage 7-30 days) were 19, 39, 40, 50, 61, 65, 68 (2), 74, 82, 86, 94, 96, 101, 103, 109, 126, 142, 145, 147, 149, 150, 155, 180, 182, 206, 216, 218, 231, 236, 279 and 330 mg/kg. The Meeting estimated a maximum residue level of 400 mg/kg and an STMR of 117.5 mg/kg for the hay or fodder (dry) of grasses.

Maize forage and fodder. US GAP allows pre-emergence application at 1.1 kg ae/ha, a directed post-emergence application at 0.56 kg ae/ha when the maize is 25-41 cm high, and a pre-harvest application at 1.7 kg ae/ha (PHI for grain 7 days).

After two applications of 2,4-D at rates totalling 1.7-2.2 kg ae/ha, the residues in rank order were 0.01, 0.03, 0.09, 0.25 (2), 0.33, 0.46, 0.61, 0.69, 0.88, 1.0 (2), 1.1, 2.7, 3.0 and 5.2 mg/kg in 16 forage samples collected at a 7-day PHI and <0.01 (14), 0.01, 0.03 mg/kg in 16 samples for silage use collected after 54-89 days.

After three applications of 2,4-D totalling approximately 3.4 kg ae/ha, the residues in fodder were 3.6, 4.2, 4.4 (2), 5.7, 6.4 (2), 9.1, 9.9, 15, 20, 25 and 30 mg/kg at 7 or 14 days after treatment.

The Meeting estimated a maximum residue level of 10 mg/kg for maize forage and 40 mg/kg for maize fodder. STMRs of 0.65 and 6.4 mg/kg were estimated for maize forage and fodder respectively.

Rice straw and fodder. The residues of 2,4-D after treatments according to GAP at 61-66 days were 1.1, 1.5, 2.1, 3.1, 5.4, 6.4 and 8.8 mg/kg. The Meeting estimated a maximum residue level of 10 mg/kg and an STMR of 3.1 mg/kg for rice straw and fodder, dry.

Sorghum, straw and fodder. The residues in the green forage in the 10 US trials described above in rank order were <0.01, 0.02 (2), 0.03 (2), 0.04, 0.06, 0.08, 0.13 and 0.14 mg/kg 30 days after treatment. The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.035 mg/kg for sorghum forage (green).

Fodder samples were harvested at maturity, approximately 82-112 days after treatment. The residues in the untreated control samples were of the same order as those in the supervised trials. The Meeting therefore concluded that the submitted data could not be used to estimate a maximum residue level for sorghum straw and fodder.

Wheat forage, straw and fodder. In the USA the first application of 2,4-D is recommended after the plant is fully tillered but before joints are formed in the stems, and the second when the grain is at the dough stage.

The wheat can be cut before the pre-harvest application and used as forage, so the forage samples were taken 7 days after the first treatment. The residues in rank order were 5, 6 (3), 6.3, 7, 8 (2), 8.5, 9 (2), 11, 14 (3), 15 (2), 16, 17, 18 (2), 19, 20 (2), 22 (2), 23 (2), 24, 25, 26, 29, 30 (2), 33 (3), 34, 35, 41, 42, 50, 54, 55, 58 and 112 mg/kg.

The residues in straw from treatments according to GAP were 2, 3, 4 (5), 5 (3), 6 (2), 7 (3), 8 (2), 11, 15 (4), 17, 18, 22, 41 and 85 mg/kg 13-15 days after pre-harvest treatment.

The Meeting estimated a maximum residue level of 100 mg/kg and an STMR of 7 mg/kg for wheat straw and fodder, dry, and an STMR of 20 mg/kg for wheat forage.

Sugar cane forage. After applying 2,4-D pre-emergence and post-emergence (at layby) to sugar cane at 2.2 kg ae/ha, the residues were <0.01(2), 0.01, 0.03, 0.04, 0.08 and 0.14 mg/kg in forage samples collected 88-92 days after the second application. The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.03 mg/kg.

Animal transfer studies

Groups of 3 cows were dosed at four dose levels equal to 1446, 2890, 5779 and 8585 ppm 2,4-D ae in the diet on a dry weight basis for 28 to 30 consecutive days. Two further groups were treated at the high dose level for 28 days and slaughtered 3 or 7 days after the last dose.

Residues of 2,4-D were detected in most of the milk samples analysed. The mean residue levels in the samples from the high-dose group reached a plateau after 7 days of treatment, showing a residue level of 0.47 mg/l throughout the remaining treatment period. The mean residues in the groups allowed 3 and 7 days of recovery decreased from the levels of 0.46 and 0.47 mg/kg at 28 days to 0.01 mg/l.

The residues in the milk from the medium-high dose groups also reached a plateau after 7 days at mean levels of 0.29 and 0.04 mg/kg respectively. The residues from the medium-low dose group became steady after the first day of treatment, having a mean level of 0.12 mg/kg throughout the remaining treatment period.

Residues of 2,4-D were also detected in most of the tissue samples analysed. The mean liver residue levels in the high, medium-high, medium-low and low dose groups were 3.1, 3.0, 1.9 and 0.12 mg/kg respectively, decreasing to 0.45 and 0.39 mg/kg after 3 and 7 days recovery respectively.

The mean residues in the kidneys from the four groups were 24, 17, 14 and 3.8 mg/kg respectively, decreasing to 0.06 and <0.05 mg/kg after 3 and 7 days recovery. The mean residues in the muscles from the four groups were 1.0, 0.76, 0.41 and 0.21 mg/kg, decreasing to 0.06 and <0.05 mg/kg after 3 and 7 days recovery, and those in the fat were 2.2, 2.5, 0.59 and 0.42 (those in the medium-high group being highest), and were 0.07 and <0.05 mg/kg after 3- and 7-day recovery periods.

Thus the highest residues were in the kidneys, followed in decreasing order by liver, fat, muscle and milk. This relationship was generally consistent in all four dose groups. The residue levels were generally dose-dependent, except in fat where the mean residue in the high dose group was slightly lower than that in the medium-high group, indicating that a plateau level had been reached in fat.

The highest exposure to 2,4-D residues will arise from the use of the herbicide on pasture, where the highest residues were 358 mg/kg in grass forage. With the assumption that the maximum daily feed consumption of a dairy cow (body weight 550 kg) is 20 kg on a dry matter basis, of which 60% is grass forage containing 25% dry matter, the intake may be calculated as follows.

358 mg/kg on a wet weight basis is equivalent to 1432 mg/kg on a dry matter basis (358 + 0.25).

Grass forage forms 60% of the diet and therefore contributes 859.2 ppm total feed on dry matter basis (1432 x 0.6).

Hence the dietary intake is 859.2 x 20 / 550 = 31 mg/kg bw/day.

The lowest dose in the feeding study was 50.6 mg/kg bw/day but, as a nearly linear relation between dose and residue level with its graph passing through the origin was established, the Meeting concluded that an extrapolation downwards to the estimated actual intake was justified in this case. The following Table shows the highest and the mean measured and extrapolated residues. Maximum residue levels were estimated from the highest extrapolated residue, and STMRs from the medians of the mean extrapolated residues for estimation of the maximum residue level and the STMR respectively.

Dose, group	Residues, mg/kg									
mg/kg bw/day	Milk		Liver		Kidney		Muscle		Fat	
	highest	mean	highest	mean	highest	mean	highest	mean	highest	mean
(50.6) Actual	(0.07)	(0.04)	(0.2)	(0.12)	(6.5)	(3.8)	(0.24)	(0.21)	(0.51)	(0.42)
31 Extrapolated	0.043	0.025	0.12	0.074	3.98	2.33	0.15	0.13	0.31	0.26
(99) Actual	(0.18)	(0.12)	(2.4)	(1.9)	(18)	(14)	(0.51)	(0.41)	(0.75)	(0.59)
31 Extrapolated	0.056	0.038	0.75	0.59	5.64	4.38	0.16	0.13	0.23	0.18
(189) Actual	(0.59)	(0.29)	(3.5)	(3.0)	(29)	(17)	(1.1)	(0.76)	(3.6)	(2.5)
31 Extrapolated	0.097	0.048	0.57	0.49	4.76	2.79	0.18	0.12	0.59	0.41
(276) Actual	(0.87)	(0.47)	(3.8)	(3.1)	(24)	(24)	(1.0)	(1.0)	(2.3)	(2.2)
31 Extrapolated	0.098	0.053	0.43	0.35	2.7	2.7	0.11	0.11	0.26	0.25

[1]Residues found in the feeding study are in parentheses

The Meeting considered that liver and kidney should by combined as "edible offal", with the residues found in kidney, and estimated maximum residue levels of 0.1 mg/kg for milk, 5 mg/kg for edible offal and 0.2 mg/kg for meat and STMRs of 0.043 mg/kg for milk, 2.745 mg/kg for edible offal and 0.125 mg/kg for meat, and recommended the withdrawal of the CXLs for milks and milk products (0.05* mg/kg). No maximum residue level or STMR was estimated for fat as the results appeared to be atypical.

A metabolism study in hens showed that about 90% of the dose was recovered in the excreta. The edible tissues and eggs contained <0.1% of the total dose. The highest exposure to 2,4-D residues will arise from wheat and rye grain in which the highest residue found in the supervised trials was 1.4 mg/kg and maximum residue levels of 2 mg/kg and STMRs of 0.22 mg/kg were estimated. With the assumption that the daily maximum feed consumption of a chicken (bw 1.9 kg) is 0.12 kg on a dry matter basis, consisting of 80% wheat grain (89% dry matter) and 20% rye grain (88% dry matter), an intake of 2.25 ppm can be calculated from the maximum residue level. Therefore, no residues higher than 0.002 mg/kg (0.1%) could be expected theoretically in edible tissues and eggs. The Meeting estimated STMRs of 0 for poultry meat, edible offal and eggs, and maximum residue levels for poultry meat and edible offal of 0.05* mg/kg as a practical limit of determination. The Meeting estimated a maximum residue level for eggs at the LOD of 0.01* mg/kg to replace the CXL of 0.05* mg/kg.

Processing

Studies have been carried out to determine the effect of processing on residues of 2,4-D in lemons, maize, rice, sorghum, wheat and sugar cane.

Lemons containing 0.51 mg/kg 2,4-D (median) were processed to juice, wet and dry pulp, molasses and oil, which contained median residues of 0.05, 0.45, 1.9, 2.0 and <0.5 mg/kg respectively. The corresponding mean processing factors were 0.1, 0.88, 4.7, 4.3 and <1. The Meeting applied these factors to the STMRs of 0.05 mg/kg for oranges and grapefruit, and estimated STMR-Ps of 0.005 mg/kg for juice, 0.044 mg/kg for wet pulp, 0.235 mg/kg for dried pulp, 0.215 mg/kg for molasses and 0.05 mg/kg for oil.

The processing data on maize indicate that residues of 2,4-D do not concentrate in any of its processed commodities used for food or feed. In grits, meal and flour, the 2,4-D residues (0.04, 0.05 and 0.05 mg/kg respectively) were of the same order as in the grain (0.06 mg/kg). In aspirated maize grain fractions the residues of 2,4-D were approximately 37 times those in the grain. In view of the chemical nature of the compound, the residues in maize oil would be lower than the LOD of 0.01 mg/kg.

Because an STMR of 0.01 mg/kg was estimated for maize grain and the residues in the processed commodities were similar to those in the raw commodity, the Meeting estimated STMR-Ps of 0.01 mg/kg for maize grits, meal and flour.

One processing study on rice was reported. Residues of 2,4-D were not concentrated in rice bran or milled white rice but were concentrated by a factor of 3 in rice hulls. No STMR-P could be estimated for milled white rice because no data were reported for the unprocessed commodity (rice with husk).

As residues of 2,4-D were not detectable in sorghum grain or its processed commodities the processing trials could not be evaluated.

Wheat was treated with excessive amounts of 2,4-D to obtain high residues (1.5 and 2.4 mg/kg) and processed to produce bran, flour, middlings and shorts. The residues were concentrated in the bran and reduced in the flour by mean processing factors of 3.65 and 0.11 respectively. From the STMR for wheat grain of 0.22 mg/kg and these factors the Meeting estimated STMR-Ps of 0.803 mg/kg and 0.024 mg/kg for wheat bran and flour respectively.

Residues from two supervised trials on sugar cane with treatment at four times the GAP rate were below the limit of determination (0.01 mg/kg). The cane from one trial was processed into molasses and sugar with residues of ≤0.01 mg/kg in molasses and <0.01 mg/kg in sugar. No STMR-Ps were estimated.

RECOMMENDATIONS

On the basis of data from supervised trials the Meeting estimated the maximum residue levels and STMRs listed below. The maximum residue levels are recommended for use as MRLs.

Definition of the residue for compliance with MRLs and for the estimation dietary intake: 2,4-D.

Commodity		Recommendation		
		MRL, mg/kg		STMR, mg/kg
CCN	Name	New	Previous	
GC 0640	Barley	W	0.5	
FB 0018	Berries and other small fruits	0.1	-	
	Berries, except grapes			0.05
FB 0264	Blackberries	W[1]	0.1	
FC 0001	Citrus fruits	W	2	
MO 0105	Edible offal (Mammalian)	5	-	2.745
PE 0112	Eggs	0.01*	0.05*	0
FC 0203	Grapefruit	0.1	2[2]	0.05
JF 0203	Grapefruit juice			0.005
	Grapefruit molasses			0.215
	Grapefruit oil			0.05
	Grapefruit pulp, dry			0.235
	Grapefruit pulp, wet			0.044
FB 0269	Grapes			0
	Grass forage (green)			193
AS 0162	Hay or fodder (dry) of grasses	400	-	117.5
GC 0645	Maize	0.05	0.05*	0.01
CF 1255	Maize flour			0.01
AS 0645	Maize fodder	40	-	6.4
AF 0645	Maize forage	10	-	0.65
	Maize grits			0.01
CF 0645	Maize meal			0.01
MM 0095	Meat (from mammals other than marine mammals)	0.2	0.05*	0.125
	Milk products	W	0.05*	
ML 0106	Milks	0.1	0.05*	0.043
GC 0647	Oats	W	0.5	
JF 0004	Orange juice			0.005
	Orange molasses			0.215
	Orange oil			0.05
	Orange pulp, dry			0.235
	Oranges pulp, wet			0.044
FC 0004	Oranges, Sweet, Sour	0.1	2[2]	0.05
FP 0009	Pome fruits	0.01*	-	0
VR 0589	Potato	0.2	0.2	0.05
PM 0110	Poultry meat	0.05*	-	0
PO 0111	Poultry, Edible offal of	0.05*	-	0
FB 0272	Raspberries, Red, Black	W[1]	0.1	
GC 0649	Rice	W[3]	0.05*	
CM 0649	Rice, husked	0.1	-	0.01
AS 0649	Rice straw and fodder, dry	10	-	3.1
GC 0650	Rye	2	0.5	0.22

Commodity		Recommendation		
		MRL, mg/kg		STMR, mg/kg
CCN	Name	New	Previous	
GC 0651	Sorghum	0.01*	0.05*	0.01
AF 0651	Sorghum forage (green)	0.2	-	0.035
VD 0541	Soya bean (dry)	0.01*	-	0
AL 0541	Soya bean fodder	0.01*	-	0.01
AL 1265	Soya bean forage (green)	0.01*	-	0
FS 0012	Stone fruits	0.05*	-	0
GS 0659	Sugar cane	0.05	-	0.01
AV 0659	Sugar cane forage	0.2	-	0.03
VO 0447	Sweet corn (corn-on-the-cob)	0.05*	-	0.05
TN 0085	Tree nuts	0.2	-	0.05
FB 0019	Vaccinium berries, including Bearberry	W[1]	0.1	
GC 0654	Wheat	2	0.5	0.22
CF 0654	Wheat bran, processed	-	-	0.803
CF 1211	Wheat flour	-	-	0.024
	Wheat forage			20
AS 0654	Wheat straw and fodder, dry	100	-	7

[1]Replaced by recommendation for berries and other small fruits

[2]Included in MRL for Citrus fruits

[3]Replaced by recommendation for Rice, husked

DIETARY RISK ASSESSMENT

The International Estimated Daily Intakes of 2,4-D, based on the STMRs estimated for 26 commodities, for the five GEMS/Food regional diets were in the range of 3 to 10% of the ADI. The Meeting concluded that the intake of residues of 2,4-D resulting from its uses that have been considered by the JMPR is unlikely to present a public health concern.

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