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The Impact of the Use of Neonicotinoid Insecticides on Honey Bees in the Cultivation of Spring Oilseed Crops in Finland in 2013–2015

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Final report

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Abstract

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The Neomehi project studied how neonicotinoid-based plant protection products affected honey bee colonies in oilseed rape and turnip rape cultivations in Finland. The final report combines the results of the growing seasons of 2013 and 2014.

The experimental protocol included four trial fields where spring turnip rape was cultivated. Each trial field was treated in a different manner with neonicotinoid insecticides: without neonicotinoids, foliar spraying with neonicotinoids (thiacloprid) against pollen beetles, and/or seed treatment with neonicotinoids (thiametoxam) against flea beetles. The plant density and crop growth were determined in the trial fields. Additionally, the number of honey bees and other pollinators was assessed with the applied line transect method during the growing season.

Five test bee colonies were located at the edge of each trial field. The performance of the bee hives was examined and the amount of bees and brood was counted 4-5 times during the summer season. A census was also done in autumn and in spring in order to acquire overwintering data. The bees and bee hive products from the test bee colonies were analysed for residues of neonicotinoids. Moreover, in the epidemiological pilot study (also called survey study in the text) of 2013-2014, residues were also analysed from samples collected as a survey from bee hives from five different geographical areas in Finland. In 2013, the sampling was optimized so that half of the bee hives were located close to oilseed cultivation and the other half far from oilseed cultivation.

The crop growth was normal in three of the trial fields during the growing season of 2013. In one trial field (seed treatment with neonicotinoids), the crop growth probably suffered because of the variation in drilling depth. In 2014, both trial fields with uncoated seed had to be redrilled after flea beetles severely attacked the young plants in the fields. Therefore, the blossoming of turnip rape in those trial fields was delayed from late July to the beginning of August. The yield was low as well. The number of honey bees in the trial fields was higher when crop growth was good and lower when crop growth was poor. In three of the four fields that were treated with foliar spraying with a neonicotinoid (thiacloprid), the number of honey bees decreased after the treatment. The number of honey bees did, however, clearly increase 2-3 days after the foliar treatment.

Both the adult and brood population dynamic curves of the test bee colonies were compared between trial sites. The adult bee population curves illustrated possible minor damages caused to the bee colonies in the sprayed test sites. The test bee colonies recovered from these casualties in two weeks. The average range of food consumption for the bees during overwintering and the overwintering index (the relation of the number of adult bees in spring compared to the number of adult bees in the beginning of overwintering) demonstrated typical levels compared to normal bee

colonies in South-West Finland and there were no difference between the trial fields. Two of the test bee colonies lost their queen during winter 2013-2014. In 2014, one of the test colonies died due to suffocation because the pollen collector at the flight entrance was blocked by drones. The second test colony was lost because of robbing by other bee colonies after harvesting. A third test colony lost its queen during winter 2014-2015 and a fourth became a drone layer in the early spring of 2015. The winter losses of the test bee colonies did not differ from the average winter losses (7% in 2014 and 10% in 2015) in the South-West of Finland.

The results of the first and second growing season did not indicate that seed coating with neonicotinoids affected the success of the bee colonies, but spraying the flowering field can be detrimental to the bee colonies that are located at the edges of the trial fields.

The results of the residue studies indicated, however, that residues of neonicotinoids migrate into bee hives with pollen and nectar and are very common residues in honey bee hives around Finland. In this case, interest is focused on the seed treatment neonicotinoids thiametoxam and clothianidin, which are the most toxic pesticides to bees. The total residue levels of thiametoxam and chlothianide, especially in nectar, resulted in an estimated exposure, which is close to the chronic and acute sublethal risk limits presented in literature. Therefore, such a risk cannot be fully excluded on the basis of these residue studies.

Keywords: Oilseed crops, oilseed rape, neonicotinoid, turnip rape, spring turnip rape, thiacloprid, thiamethoxam, clothianidin, honey bee, nectar, bee bread, seed treatment, pollinator, bee colonies

Tiivistelmä

Neomehi-hankkeen tärkein tavoite oli selvittää vaikuttavatko neonikotinoideja sisältävät torjunta-aineet pölytyspalvelussa käytettyjen mehiläispesien menestykseen ja talvehtimiskykyyn. Hankkeessa tutkittiin kahden kasvukauden ajan minkälaisia vaikutuksia rypsinviljelyssä käytettävillä, neonikotinoideja sisältävillä torjunta-aineilla on mehiläisiin suomalaisessa öljykasvin viljelyssä. Nyt julkaistava hankeraportti kokoaa yhteen kaksivuotisen Neomehi-hankkeen keskeisimmät tulokset.

Koejärjestely sisälsi neljä kenttäkoetta kumpanakin kasvukautena 2013–2014, joissa viljeltiin rypsiä. Neonikotinoideja sisältäviä insektisidejä käytettiin eri tavoin kullakin pellolla. Koepellolla joko ei käytetty neonikotinoideja tai ruiskutettiin neonikotinoidilla (tiaklopridi) kirppoja vastaan ja/tai käytettiin neonikotinoidilla peitattua (tiametoksaami) siementä rapsikuoriaisia vastaan. Kasvien kasvua ja kasvutiheyttä seurattiin, ja pelloilla vierailevien mehiläisten ja muiden pölyttäjäryhmien esiintyminen laskettiin kasvukauden aikana. Kunkin pellon laidalla pidettiin viittä mehiläispesää. Mehiläispesien kuntoa seurattiin ja mehiläisten ja niiden jälkeläisten lukumäärä laskettiin vähintään neljällä eri tarkastuskäynnillä kesän aikana. Vahvuuslaskentoja tehtiin myös syksyjen 2013 ja 2014 aikana sekä keväällä 2014 ja 2015. Tällöin saatiin tarkempaa tietoa molempien hoitovuosien talvehtimisesta. Mehiläisiin ja mehiläispesän tuotteisiin kerääntyviä neonikotinoidien jäämiä analysoitiin kaikista kenttäkokeen pesistä. Kenttäkokeen lisäksi molempina kesinä 2013–2014 kerättiin näytteitä mehiläispesistä otantana viideltä eri alueelta Suomessa (epidemiologinen pilottihanke, otantatutkimus). Vuonna 2013 otantatutkimuksen näytteet valittiin siten, että puolet pesistä sijaitsi lähellä rypsinviljelyä ja puolet kaukana.

Kasvien kasvu ja kukintojen tiheys oli normaalia kolmella koepellolla vuonna 2013. Yhdellä pellolla kasvu ei ollut niin hyvää johtuen todennäköisesti väärästä kylvösyvyydestä. Vuonna 2014 peittaamattomalla rypsin siemenellä kylvetyt kentät jouduttiin kirppojen vioitusten takia kylvämään uudestaan, jonka seurauksena niiden kukinta oli vasta heinä-elokuun vaihteessa. Pölyttäjälaskennat osoittivat, että pääsääntöisesti mehiläisten lukumäärä pellolla oli korkea, kun kasvin kasvu oli hyvä ja kukintoja runsaasti ja toisaalta taas mehiläisten lukumäärä alhainen kun kasvin kasvu heikkoa. Tällöin esimerkiksi ympäristössä olevat luonnonkasvit houkuttelivat mehiläisiä merkittävästi puoleensa. Koekentillä, jotka käsiteltiin neonikotinoidi-ruiskutuksella, ei mehiläisiä juuri havaittu heti ruiskutuksen jälkeen. Muutama päivä käsittelystä mehiläisten lukumäärä pellolla oli kuitenkin palautunut ruiskutusta edeltäneeseen tilaan.

Ensimmäisen ja toisen kauden tulosten perusteella havaittiin, että neonikotinoideilla kukkivaan kasvuston tehdyt ruiskutukset saattoivat alentaa hieman koepesien aikuisten mehiläisten määrää. Mehiläispesät kuitenkin toipuivat menetyksistä kahden viikon kuluessa. Myös talvenaikainen ruoankulutus sekä talvehtimisindeksi (mehiläisten lukumäärän suhde syksyllä ja keväällä) asettuvat tyypillisiin arvoihin, joita mehiläisyhdyskunnille on mitattu Lounais-Suomessa, eivätkä eri koekenttien mehiläispesät poikenneet toisistaan tässä suhteessa. Talven 2013–2014 aikana kaksi pesää menetti kuningattaren. Toinen pesä oli koekentällä, jota ei käsitelty neonikotinoideilla ja toinen kentällä, jossa neonikotinoideja oli käytetty siementen peittaukseen.

Hoitokaudella 2014 yksi pesistä tukehtui, kun kuhnurit tukkivat siitepölykeräimen. Toinen pesistä menetettiin koekentällä 3, kun muiden pesien mehiläiset ryöstivät sen tyhjäksi sadonkorjuun jälkeen. Talvella 2014–2015 yksi pesä menetti emonsa ja yhden pesän emo alkoi munia kuhnureita aikaisin keväällä 2015. Talvehtimistappiot eivät eroa koko Suomen keskiarvosta (7% 2014 ja 10% 2015).

Jäämätutkimusten perusteella neonikotinoidien jäämiä siirtyy siitepölyn ja meden mukana mehiläispesiin. Peittausaineiden jäämät (tiametoksaamin, klotianidiinin) ovat erittäin yleisiä mehiläispesissä ympäri Suomen. Mitatut jäämäpitoisuudet etenkin medessä johtavat arvioon altistumistasosta, joka on lähellä kirjallisuudessa esitettyjä kroonisia ja akuutteja subletaaleja riskirajoja. Jäämätulosten perusteella ei voida siis täysin pois sulkea tämäntyyppistä riskiä.

Avainsanat: öljykasvi, rypsi, kevätrypsi, mehiläinen, tarhamehiläinen

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1. Introduction

The NEOMEHI Project was launched in 2013 by the Natural Resources Institute Finland (formerly MTT Agrifood Research Finland) and the Finnish Food Safety Authority Evira. The project studied how neonicotinoid-based insecticides used in the cultivation of spring oilseed crops (oilseed rape and turnip rape) affected honey bees (*Apis mellifera*).

The aim of the Neomehi project is to provide answers to the following questions:

1. Do neonicotinoids influence the number of pollinators in the field environment?
2. Do neonicotinoids influence the performance of beehives?
3. Does the use pattern of neonicotinoids (seed treatment and/or foliar sprayings) cause differences in their impact?
4. Are there residues of neonicotinoids in the honeybee colonies (worker honey bees, brood, bee bread, nectar, honey, pollen) used in the pollination service in the oilseed fields?
5. What are the influences on oil seed crop cultivation if the use of neonicotinoids is limited or banned?

In addition, within the framework of the project, reliable analytical methods were built for the determination of pesticide residues in plant material, bees, and different bee hive matrices.

2. Influences of the banning the use of neonicotinoid seed coating products on rape plants in Finland

According to the results of yearly agricultural land use, the cultivation of spring oilseed crops collapsed in Finland in 2014. Approximately 93% of the cultivated field area of rape plants has been used for spring oilseed crops and only 7% for the winter varieties of oilseed crops. The cultivated area for oilseed rape crops was 43,500 hectars in 2014, which was nearly 50% lower than the average cultivated area (86,400 ha) in Finland in 2003-2013. The willingness of farmers to cultivate spring oilseeds had obviously decreased. After the lowest point of 2014, the total area of oilseed crops increased to 57,300 ha in 2015. The mean of the total cultivated area was 1,970,900 ha in 2013-2015. (Natural Resources Institute Finland 2015).

About 5% of the area of spring oilseed plants has been cultivated without seedcoating in the the country yearly during this decade. According to the available statistics, the total sales of neonicotinoids thiametoxam+clothianidin (kg *a.i.*) was 8,207 kg in 2010, 2,608 kg in 2011, 3,186 kg in 2012 and 0 kg in both 2013 and 2014 (Tukes 2015). However, the whole amount is not necessarily used in Finland. Since some might have been delivered back to the production companies.

The campaigns for farmers to have oilseed crops in crop rotations and the temporary permission for the use of neonicotinoid treated seed in drillings of spring turnip rape and spring oilseed rape had an impact on and increased the cultivation area. In addition, the spring of 2015 came very late in Finland and some farmers may have changed their cereals to spring turnip rape just before the drilling.

The risk of insects injuring young spring turnip rape and spring rape plants is, during many years, doubtlessly a cause for yield losses when not using seed treatment. The main species of insect that causes damage is the flea beetle (*Phyllotreta undulata).* Replacing seed treatment with periods of foliar sprayings is also a less sustainable alternative. Furthermore, farmers appear to be very responsible and they most likely do not want to use plant protection products that are launched to be harmful to the natural pollinators and honey bees used in the oilseed fields.

However, the Finnish Pesticide Safety Authority TUKES allowed farmers to use rape plant seeds that were coated with neonicotinoid plant protection products for sowings until the end of June 2014 if the products had been produced before the ban of December 2013. In the 2015 drillings, a temporary permission to use neonicotinoid treated spring turnip rape and spring rape was also granted. The cultivation area of the plant in Finland from 1951 to 2015 is described in Figure 1 of the oilseed crops field area. It is emphasized that spring oilseeds, spring rape, and spring turnip rape are the primary oilseeds cultivars. Winter oilseeds sowed in autumn are suitable for only a very limited field area in Finland. Their problem is the uncertain wintering in the Finnish climate.

The influences of the possible decrease in the cultivation of spring oilseed crops due to a lack of plant protection products for seed treatment appear to, in short, be the following:

As a direct result, the amount of pressed turnip rape and rape seeds used for food oil and biofuel will decrease significantly. The same will apply to the use of rape crush as one of the main protein sources for feeding cattle. This lack of raw material is due to the farmers' unwillingness to cultivate spring oilseeds. This production and breeding in the oilseed crop industry will be decreased primarily because of the lack of proper seed coating products for spring oilseeds.

The beekeepers' forage plants will decrease significantly, since oilseed crops are the main cultivated forage plants for honey bees (*Apis mellifeira*) when the plants are flowering in June and July. The decreases in the areas of oilseed fields for honey bees to forage result in economic losses for beekeepers.

Deep root plants, such as turnip rape and rape, are beneficial for improving clay soils for growing many plants thereafter, especially cereals. If oil seed crops are not cultivated in the crop rotation in

the field, there will be a risk that the structure of the cultivated land will suffer and that extra yields of other crops will be attained.

In this project, it was possible to only outline some influences and direct and indirect consequences of there being fewer or no seed coating products for spring oilseeds. New replacement products for these purposes are not yet in the market and as such, there will be a risk of farmers finishing the cultivation of spring oilseeds in Finland without the possibility of seed treatment. Even if the new techniques were adapted to in the next few years, there will nevertheless be a risk that the infrastructure that includes important know-how regarding the matter will be lost. Taking everything into consideration, it was neither possible nor relevant to investigate the different socio-economic factors widely in this project.

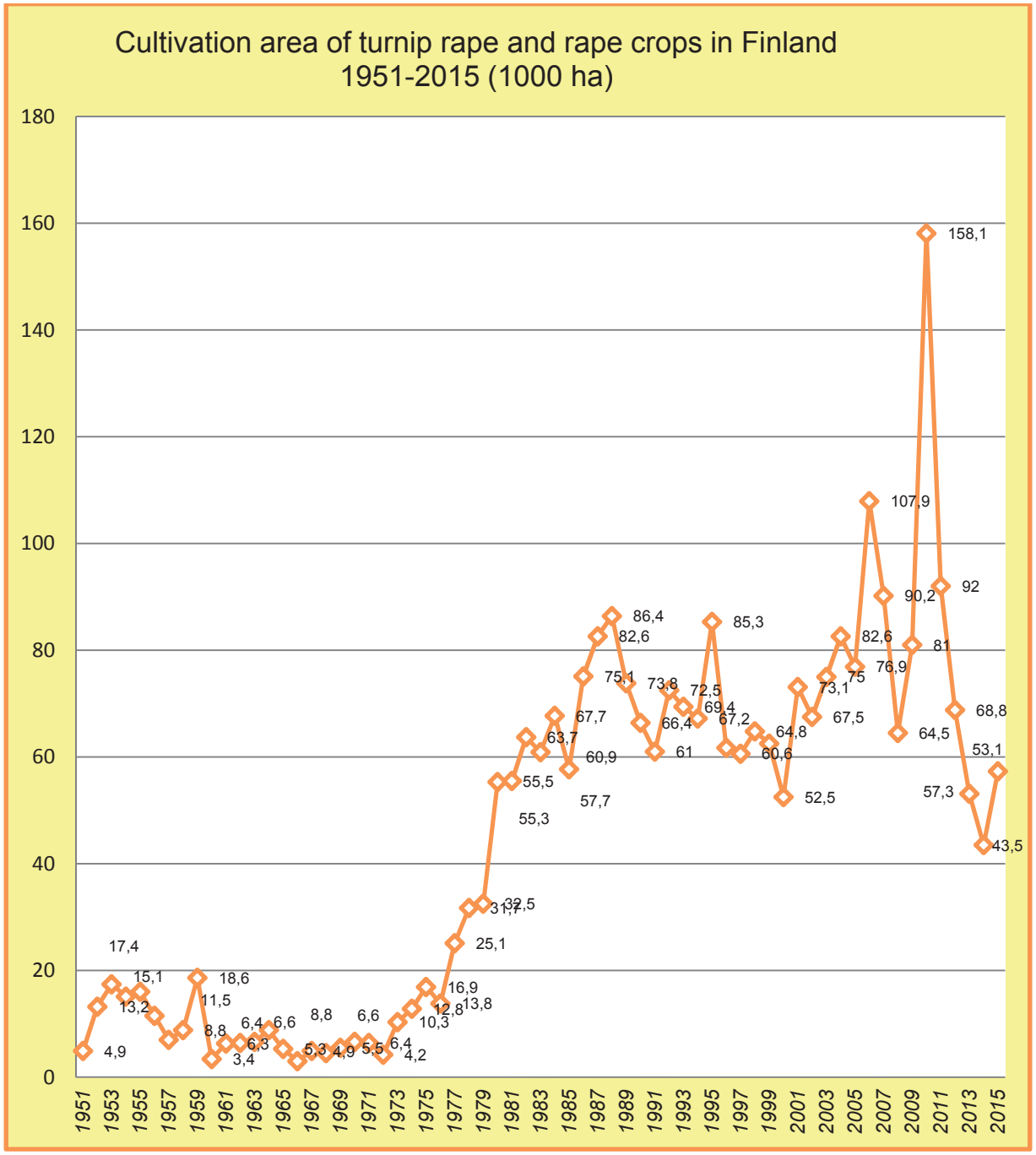

Figure 1: The cultivation area of oilseed crops in Finland from 1951 to 2015. (Natural Resources Institute Finland 2015)

3. Experimental set-up

The project consisted of two parts: a field study (part A) and an epidemiological pilot study, which is also called a survey study (part B). The project was established in spring 2013 and lasted until the end of 2014. The overwintering of the test beehives during the second year was assessed in 2015.

3.1. Part A. Field study

The field study was conducted in co-operation with local beekeepers and local farmers. A research unit consisted of four trial sites where spring turnip rape was cultivated. A trial site mentioned in the text consisted of a trial field (spring turnip rape) and five test bee hives.

The identification of the trial sites in 2013 and 2014, the dates of activities, the plant protection data, and the cultivation methods are presented in Appendix 1.

The trial fields were drilled using either direct drilling or conventional drilling in both 2013 and 2014. In 2013, the drilling of trial fields 1 and 4 was delayed in order to decrease the risk of damage that flea beetles (*Phyllotreta* sp.) cause on young turnip rape plants. As for trial fields 2 and 3, they were treated against flea beetles with pyrethroids Sumi alpha 5 FW (esfenvalerate 50 g/l a.i.) and/or Decis Mega EW 50 (deltamethrin 50 g/l a.i.) one to three times until the tunip rape began flowering (Table 1). The plant density was counted once per trial site at four randomly chosen locations in each field just after the turnip rape had flowered. In 2014, all trial fields were drilled in May. While they were germinating, however, the young turnip rape plants were very severely damaged by flea beetles in both trial fields 1 and 4 (no seed treatment). Because of this, the fields had to be drilled again to produce a proper crop stand of turnip rape that would attract foraging honey bees. This redrilling of turnip rape was completed in June, which delayed the flowering of these trial fields significantly. The delay amounted to nearly one month in comparison to the flowering of the turnip rape in trial fields 2 and 3. Nevertheless, the plant density of each trial field was counted during the flowering of turnip rape.

The trial fields had the same protocol for the use of neonicotinoid insecticides in both 2013 and 2014 (Table 1). On trial fields 2, 3, and 4, neonicotinoids (thiametoxam and /or thiacloprid) were used for seed treatment and/or foliar sprayings. In trial fields 2 and 3, the seed was treated with thiametoxam. Moreover, the foliar sprayings with thiacloprid against pollen beetles in trial fields 3 and 4 were conducted close to full flowering, at crop stage BBCH 64-65, in both locations. No neonicotinoids were used in trial field 1.

The neonicotinoid product used for the seed treatment of spring turnip rape was Cruiser OSR (thiamethoxam 280 g/l, metalaxyl-M 32.3 g/l, fludioksonil 8 g/l). It was used at the product rate of 15 ml/kg per seed. The amounts of active ingredients/kg per seed were thiamethoxam 4.2 g a.i., metalaxyl-M 0.48 g a.i. and fludioksonil 0.12 g a.i. The variety of spring turnip rape was Apollo (Batch code 357-01059B). According to the seed treatment analysis report, the rate of thiamethoxam was 92% of the target rate, which is acceptable (Appendix 2). The foliar sprayings with a neonicotinoid were conducted with Biscaya OD 240 (thiacloprid 240 g/l) at the product rate of 0.25 l/ha and 0.35 l/ha. The used dose rate was 0.25/l/ha in trial field 3 in 2014, which was lower than 0.35 l/ha. The amounts of the active ingredient of the thiacloprid were 60 g a.i. and 84 g a.i., respectively. The plant protection products that were used were approved by the Finnish Safety and Chemicals Agency TUKES and applied at the approved product rates.

Table 1. The table for insecticide treatments in the field study in 2013 and 2014. Detailed treatment data in Appendix 1.

Trial Site	Treatments with neonicotinoids	Treatment with other insecticides
1	- no seed treatment - no foliar spraying	- synthetic pyrethroid (product Sumi alpha 5 FW) as foliar application against flea beetle until 2-4 true leave stage - synthetic pyrethroid (product Sumi alpha 5 FW) as foliar application against pollen beetles until beginning of flowering of turnip rape
2	- seed treatment with thiametoxam 280 g/l +metalaxyl-M 32.3 g/l+fludioxonil 8 g/l (product Cruiser OSR) 15 ml product/1 kg turnip rape seed - no foliar spraying	- synthetic pyrethroid (product Sumi alpha 5 FW) as foliar application against flea beetle until 2-4 true leave stage - synthetic pyrethroid (product Sumi alpha 5 FW) as foliar application against pollen beetles until beginning of flowering of turnip rape
3	- seed treatment with thiametoxam 280 g/l +metalaxyl-M 32.3 g/l+fludioxonil 8 g/l (product Cruiser OSR) 15 ml product/1 kg turnip rape seed - foliar application of thiacloprid (product Biscaya OD 240) 0.25 l[1] and 0.35 l product/ha against pollen beetles at the beginning of flowering of turnip rape	- synthetic pyrethroids (products Sumi alpha 5 FW and Decis) as foliar application against flea beetle until 2-4 true leave stage - synthetic pyrethroids (product Sumi alpha 5 FW) as foliar application against pollen beetles until beginning of flowering of turnip rape
4	- no seed treatment - foliar application of thiacloprid 240 g/l (product Biscaya OD 240) 0.35 l product/ha against pollen beetles at the beginning of flowering of turnip rape	- synthetic pyrethroid (product Sumi alpha 5 FW) as foliar application against flea beetle until 2-4 true leave stage - synthetic pyrethroids (product Sumi alpha 5 FW) as foliar application against pollen beetles until beginning of flowering of turnip rape

[1] 0.25 l/ha was used in trial field 3 in 2014 although the planned dose rate was 0.35 l/ha

The cultivated crops around each trial field were taken into consideration by choosing the trial fields so that there would not be other oil seed crops close to the trial field. The test bee colonies were located at least 1 km from other oilseed fields. Furthermore, the cultivation of oilseed crops on fields within a 3 km radius from the test bee colonies in each trial site was charted in 2013 (Appendix 3). Appendix 4 includes more detailed information on the proximity of oilseed cultivation concerning the hives on trial field 1 (control field 2013 and 2014). The test bee colonies of trial site 1 were held at MTT between 24 and 28 June, 2013 before being transferred to trial field 1.

The area of each trial site was targeted to be between 1 and 2 hectars. In practice, the areas were 1.4-1.7 ha in 2013. In 2014, by comparison, the trial areas were 1.9-4.1 ha.

Five test bee colonies were placed at the edge of each trial field. The test bee colonies were owned and managed by Hunajaluotsi Ltd.

In order to comprehensively estimate the honeybees' exposure to the neonicotinoids, the occurence of neonicotinoid residues (chlothianidin, thiacloprid) was studied in the plant and hive samples of each trial site. Additionally, the residues of some other pesticides that were included in the seed treatment (fludioxonil, metalaxyl-M) and foliar spraying products (esfenvalerate, deltamethrin) were also monitored in the hive samples.

The plant samples were collected during the flowering stage, and the floral parts of the plants were removed for the analyses.

The samples taken from the bee colonies in 2013 and 2014 included nectar (newly foraged honey near the brood area), honey (harvested honey), and bee bread (=perga=fermentated pollen near the brood area). Additionally, pollen load samples were collected with pollen traps from the flight entrances. Adult bees were also sampled from the brood combs of all the bee colonies inside the test colonies, as well as from the ground within a six-meter radius from the front of the bee colonies on foliar spraying test sites in 2013. All samples were frozen after collection.

The sampling times were scheduled in such a manner that both the blooming of the vegetation and the spraying times of the neonicotinoids were taken into consideration (Table 2). Expections were the honey and bee bread samples that were mainly collected outside the full flowering period which was not optimum time for the study of residues. The procedure was to collect dead bees from the front of the test colonies on non-treated and on sprayed test fields for residue analysis, especially if an increase in the number of dead bees had been observed. However, such an increase was not observed in the field study in front of the test colonies in 2013 or in 2014, and only a small number of bees was recovered for sampling in 2013. In 2014, no dead bees were collected for for residue analysis.

The relative distribution of *Brassica* pollen was analysed microscopically from nectar, honey, beebread, and pollen samples in order to acquire information on the relative amount of Brassica-originated material in the samples.

The number of pollinators in turnip rape was assessed at all four trial field sites between the start of flowering (BBCH 59) and full flowering (BBCH 65) during the June and July growing seasons of 2013 and 2014. The pollinators included honey bees, as well as bumble bees, flower flies, and butterflies. The number of insects was counted along a fifty-metre line utilizing the linetransect method. The aforementioned line was always placed in the centre of each spring turnip rape area.

Table 2. The table for the samplings in the field study in 2013 and 2014.

Time of sampling, BBCH[2] crop stages when possible	Counting of pollinators	Plant	Bee	Pollen	Samples from hives
plant stage, when plants are at 2-4 true leaves BBCH 12-16					
bud stage BBCH 50-59	Line method[3]		Control samples if there are bees in the counts collection of individual bees entering hives		
flowering stage BBCH 65-69	Line method[3]	Flowers Two samples, both with 15 subsamples per trial field, 3-4 timepoints per field	crop stand and from test bee colonies	pollen collection from flight entrance (2 hives/field); at least four time points per field	nectar, bee bread (4-5 hives/field); 1-2 time points[4]
After season					honey (4-5 hives/field); one time point

[2]BBCH Phenological growth stages of turnip rape: BBCH 63-64 Principal growth stage 6: Flowering 30%-40% of main raceme open, BBCH 65 Full flowering i.e. 50 % flowers on main raceme open, older petals falling

[3]Krebs 1989

[4]nectar and bee bread samples were typically collected at beginning of flowering or at end flowering. Two nectar and two bee bread samples were collected at the full flowering stage.

3.1.1. Production and management of test bee colonies

Twenty honey bee colonies and ten spare colonies were produced by shaking 25 kg of young bees from ordinary bee hives into a large swarm box on 28 May, 2013. Of these bees, 750 g were then placed into a five-frame, new Farrar hive body on wax foundation frames after fasting for 24 hours in a dark room of 17º C. Each swarm was situated in one half of the divided Farrar hive body. Moreover, young queens and 2 l of 50% sugar syrup were provided to every swarm with a top feeder. The swarms were kept in a dark room with a regulated temperature of 18 º C for 48 hours after establishment. The colonies were transferred to an isolated forest apiary, Perho, located in Tammela, where the nearest cultivation areas were at least 5 km away from the bee colonies. The queens and laid eggs were inspected after one week and the feeding was continued. After two weeks, all colonies were moved to their own hive body by supplying five more wax foundation frames to each colony. At the same time, 350 g of young bees were supplied to the colonies. The beehives were moved to the test fields when the first turnip rape flowers were in bloom and withdrawn when the flowering was over. Due to logistical reasons, the test bee colonies intended for trial site 1 were temporarily held at MTT (MTT Lypsyasema, Appendix 3) between 24 and 26 June, 2013 before being transferred to trial field 1. The amount of bees and brood was counted four times during the season. The spare colonies that were left in the confined forest bee yard constituted an additional test site in 2013. As a result, the hives' development was followed in the same manner as the hives in the other trial sites.

The test bee colonies were transferred to overwintering bee yards after harvesting at the end of August in both years. In fall of both 2013 and 2014, the bee colonies were fed with 67% sugar syrup and varroa treatment was conducted with Thymol 12 g/bee colony on 26 August, 2013 and 1 September, 2014. Moreover, oxalic acid trickling (3.2% solution) was provided to the test colonies without brood on 28 October, 2013 and on 4 December, 2014. The number of winter bees was estimated during the oxalic acid treatment. The number of dead bees during the winter was measured from the bottom board winter debris immediately after the cleansing flight, but only in 2014. The first spring census was conducted between 22 and 24 March, 2014.

The beehives were weighed in fall after winter feeding and in spring before nectar flow. The winter food consumption and over wintering index (number of adult bees in spring / number of adult bees in autumn) were calculated.

The test bee colonies were moved from their overwintering bee yards to an isolated forest apiary, Perho, on 10 June, 2014. The colonies were placed onto test fields 1, 2, 3, and 4 on 1 August, 30 June, 30 June, and 24 July, respectively, and moved to their overwintering apiaries on 25 August, 2014. The spring census for the test colonies was conducted on 11 May, 2015.

3.1.2. Pollen analysis of nectar, honey and bee bread

The nectar flow and honey samples were prepared by the methodology recommended by the International Commission of Bee Botany and the International Honey Commission (Louveaux et al. 1978). The pollen analyses were performed using 400 * magnification and all the pollen grains of each plant species, family and group were counted separately until the total number of 300 grains was exceeded. The percentage of each species, family or group was calculated in the 2013 samples. In 2014, the pollen grains were counted until the total number of 300 was exceeded, and the groups were separated to *Brassica* species and others.

The pollen loads collected from the entrances of the bee hives were classified into unique groups by colour, and the plant species representing each group was identified by microscope inspection. The percentage relation of *Brassica* and all other plant species was calculated.

The bee bread samples were homogenised and 5 g of the sample was placed into a centrifuge tube with 10 ml of distilled water. Of the homogenised sample, 0.1 ml was collected into an object glass with a micropipette and prepared after (Loveaux et al. 1997). The pollen analyses were performed using 400* magnification, and all the pollen grains of each plant species, families and groups

were counted separately until the total number of 300 grains was exceeded. The percentage of each species, family or group was calculated in the 2013 samples. In 2014, the pollen grains were counted until the total number of 300 was exceeded and the groups were separated to *Brassica* species and others.

3.2. Part B. Epidemiological pilot study

Part B of the research protocol was connected to another project operated by the Finnish Food Safety Authority Evira (national reference laboratory for honey bee health) in conjunction with the pan-European epidemiological study on honey bee colony losses (EPILOBEE 2012-2014).

The effects of the neonicotinoids on honeybees were analysed in two parts:

1) Residue analysis

Nectar and bee bread samples were also collected for residue analyses. In 2013 samples from 18 apiaries of the EU project from the South-West of Finland near the cities of Jokioinen and Salo were collected during turnip rape flowering by the inspectors of the EU project. The apiaries were chosen so that beehives from the same beekeeper were situated close to an oilseed field and far from an oilseed field. Samples from at least two beehives of each apiary were collected. In 2014, nectar and bee bread samples were collected from the five different geographical areas including Åland archipelago altogether from 85 apiaries (205 beehives). The sampling was timed with the inspection visits of the EU bee health project. Therefore, the sampling was not optimized, for example, for the time of flowering or for the proximity of oilseed cultivation. The neonicotinoid compounds used for turnip rape cultivation in Finland (thiamethoxam, chlotianidin, acetamiprid, thiacloprid) were prioritized in the residue analyses but residues of pyrethroids (lambda-cyhalothrin, esfenvalerate, tau-fluvalinate, deltamethrin) and fungicides (iprodione, fludioxonil, metalaxyl-M) were also analysed.

2) The relationship between the proximity of oilseed cultivation, hive strength and neonicotinoid residues

The effect of oilseed cultivation on beehive strength was analysed with the 322 apiaries followed in the EPILOBEE project in 2012-2013 and 2013-2014. The effect of oilseed cultivation on neonicotinoid amounts was analysed with the 18 apiaries surveyed for residues in 2013.The locations of the turnip rape fields close to the surveyed apiaries were taken into consideration when assessing beehive strength. The hive streght was assessed on scale 0-5 according to the EPILOBEE project protocol. The information on the nearby turnip rape fields was obtained from the national field plot register (official database of field crop cultivation by MAVI - Agency for Rural Affairs). Using the coordinates of the apiary, the total area of turnip rape and oilseed rape fields within 1-3 km and the distance to the nearest field were calculated. The relationship between colony strength/residue amounts and cropping intensity was examined using linear or non-linear regression analysis. In this report the results of the 18 pilot apiaries are presented.The final results of the study will be reported in the Final Report of project MMM 1042/311/2012 (EU-komission Mehiläisten terveys –pilottihanke) before 30 March, 2016.

4. Results

4.1. Crop growth in the field study

The cultivation of spring turnip rape is challenging, and there are many concerns, which need to be in good order to produce a good growth of the plant. Overall, the aim of the trial fields' maintenance was to achieve as good a crop growth and as rich a flowering of spring turnip rape as possible in order to attract as many honey bees and other pollinators as possible.

The results of the cultivation of spring turnip rape in 2013 are described in Table 3. The plant density varied considerably between the trial fields. The crop growth of turnip rape was normal in trial sites 1, 3, and 4 in 2013. In trial site 2, the crop growth probably suffered due to insufficient drilling depth in some areas of the field. The crop density was too low, which resulted in varying crop growth.

The drilling of spring turnip rape with untreated turnip rape seeds functioned well on the trial sites in 2013. The seed germinated rather well and the leaf development was proper on trial fields 1 and 4. A rather good crop stand of turnip rape was acquired in both locations in 2013. The insect pest pressure (both flea beetles and pollen beetles) was lower than normal in 2013.

The germination of turnip rape was poor in trial sites 1 and 4 (no seed treatment) due to the fact that young plants were severely infested by flea beetles in 2014. Therefore, both trial sites were re-drilled in June, which caused late flowering in August 2014. The results of the trial sites harvested yields are presented in Tables 3a and 3b.

Table 3a. Number of drilled seeds, flowering plants, plant density, yield results and tsw (thousand seed weight) of the trial fields in 2013. *The crop stand was very uneven in trial site 2. The plant density and the overall crop growth of spring turnip rape in trial site 2 was estimated after the decline of flowering as follows: ⅓ of the field area was slightly normal, ⅓ was thin and ⅓ of the area was open with hardly any spring turnip rape plants.

Trial Sites, Location, Cultivated area of turnip rape, Seeding rate in ha	**Number of drilled seeds x10^6 in field**	**Number of flowering plants in m^2**	**SD**	**Plant density. Percent of normal 150 plants per m^2**	**Number of flowering plants x10^6 in field**	**Seed yield kg in ha**	**SD**	**TSW of seed yield g**	**SD**
Site 1, Somero, 1.7 ha, 13 kg	9.09	68.25	±12.87	45.5	1.16	1700		2.43	±0.04
Site 2, Forssa, 1.7 ha, 10 kg	6.83	70.50 36.75 0 Mean 35.75*	±11.0 ±6.08 Mean 5.69	47.0 24.5 0 Mean 23.8	0.61	1600 600 0 Mean 733		2.49	±0.01
Site 3, Koski, 1.7 ha, 6 kg	4.10	109	±24.09	72.7	1.85	2000		2.49	±0.01
Site 4, MTT, 1.4 ha, 10 kg	5.76	150.75	±29.03	100.5	2.11	2259	±203.61	2.43	±0.04

Table 3b. Number of drilled seeds, flowering plants, plant density, yield results and tsw (thousand seed weight) of the NEOMEHI trial fields in 2014. The seed yields were estimated by the farmer, except in trial site 2 where the yield was harvested and measured by the plot combiner.

Trial Sites, Location, Cultivated area of turnip rape, Seeding rate in ha	Number of drilled seeds x10^6 in field	Number of flowering plants in m^2	SD	Plant density. Percentage of 150 normal plants per m^2	Number of flowering plants x10^6 in field	Seed yield kg in ha	SD	TSW of seed yield g	SD
Site 1, Somero, 2.9 ha, 8 kg	9.54	51.75	±4.32	34.5	1.51	750		2.41	±0.04
Site 2, MTT AXI, 2.0 ha, 10 kg	7.90	110	±3.56	73.3	2.17	1540	±86.74	2.57	±0.01
Site 3, Jokioinen Peto-oja, 4.1 ha, 8 kg	13.28	216	±23.37	144	8.88	900		2.72	±0.07
Site 4, MTT PII, 1.9 ha, 8 kg	6.44	68.5	±15.50	45.7	1.26	800		2.41	

4.2. Counting of pollinators in the field study

The data on the number of pollinators in the trial fields in 2013 and 2014 is presented as graphs in Figures 2 and 3. The number of pollinators, such as honey bees, bumble bees, flower flies, and butterflies foraging in the turnip rape crop stand was counted on a fifty-metre line in each trial site from the beginning of flowering to its decline. According to the results of 2013-2014, a spring turnip rape crop in good growth will evidently attract more pollinators, such as honey bees, than a poor crop stand. The number of other pollinators besides honey bees was rather low in the trial fields, except for the turnip rape on trial sites 1 and 4, which did not bloom until August in 2014. The late flowering may specifically have caused an increase in the number of flower flies. Then again, this might have been a result of the environment or the habitat around the trial fields rather than a result of the treatments conducted in them. In three of the four cases, however, the number of honey bees and bumblebees was low for one to two days immediately after the foliar spraying with thiacloprid in 2013-2014. After the decline period, the number of pollinators distinctly increased again.

The number of honey bees in trial site 3 at 5 DAT (days after treatment) and the number of honey bees and bumble bees in trial site 4 at 3 DAT and at 4 DAT were the highest of the entire period in 2013. The number of honey bees was high when the crop growth was good, such as in trial field 1 (mean 122.5±139.9), and it was low when the crop growth was poor, as illustrated by trial field 2 (mean 34±40.4). The number of honey bees in trial field 1 collapsed once when the weather was cloudy and slightly rainy. In 2014, the fields on both trial sites 1 and 4 were drilled again after flea beetles had severely attacked the young plants on the sites. Due to later flowering, the pollinators were counted 2-3 weeks later than on trial sites 2 and 3. The number of honey bees was the highest in trial field 1 (control field) (mean 198±18.7). After counting, it became apparent that trial sites 2 and 4 attracted fewer honey bees (means 26.3±6.7 and 64.7±16.5, respectively). In fact, the lower number of honey bees was the cause of the poor flowering of turnip rape on trial site 4. The fairly rainy period during the flowering of turnip rape may also have decreased the number of honey bees on trial sites 2 and 3.

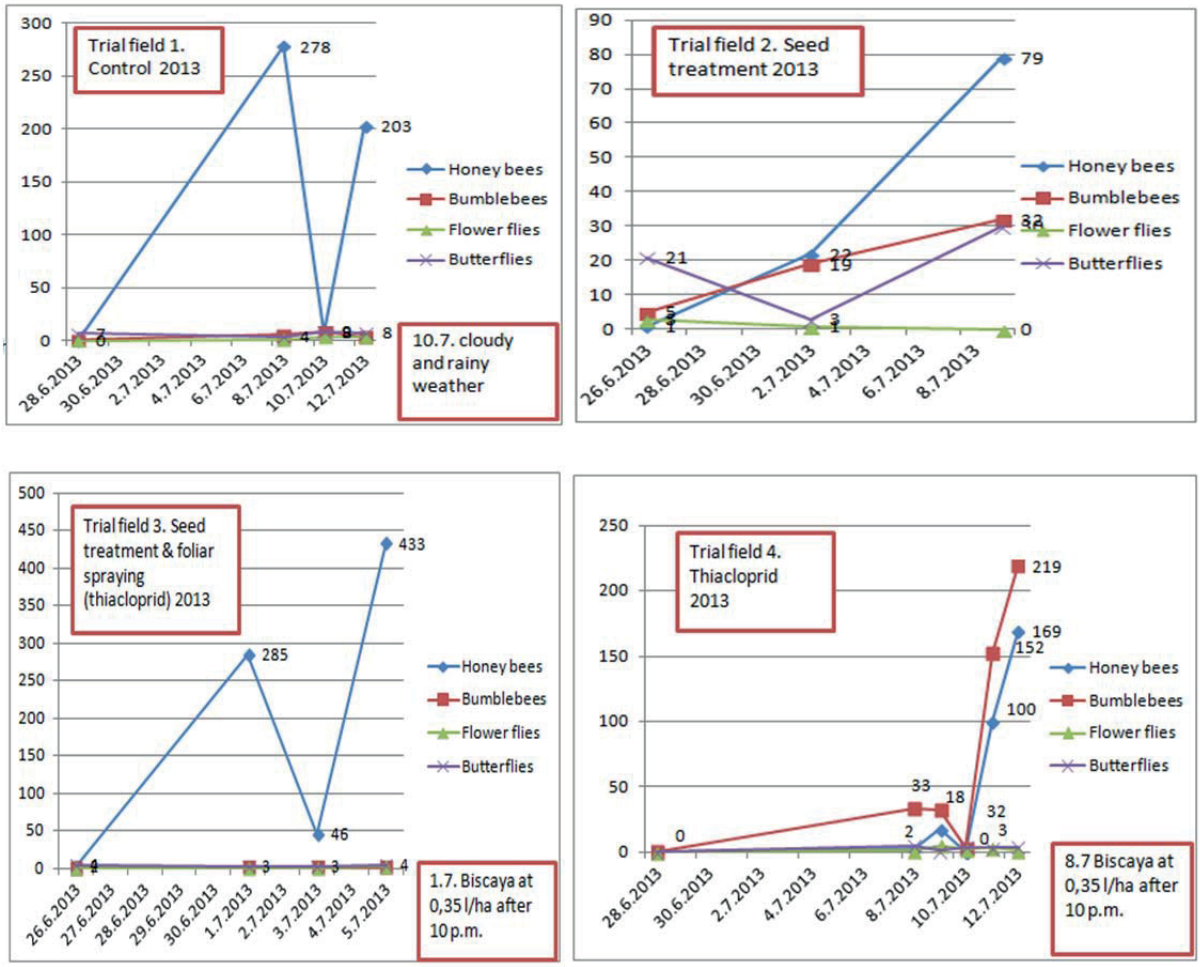

Figure 2. Number of honey bees, bumble bees, flower flies, and butterflies in the field study during the flowering of turnip rape in 2013.

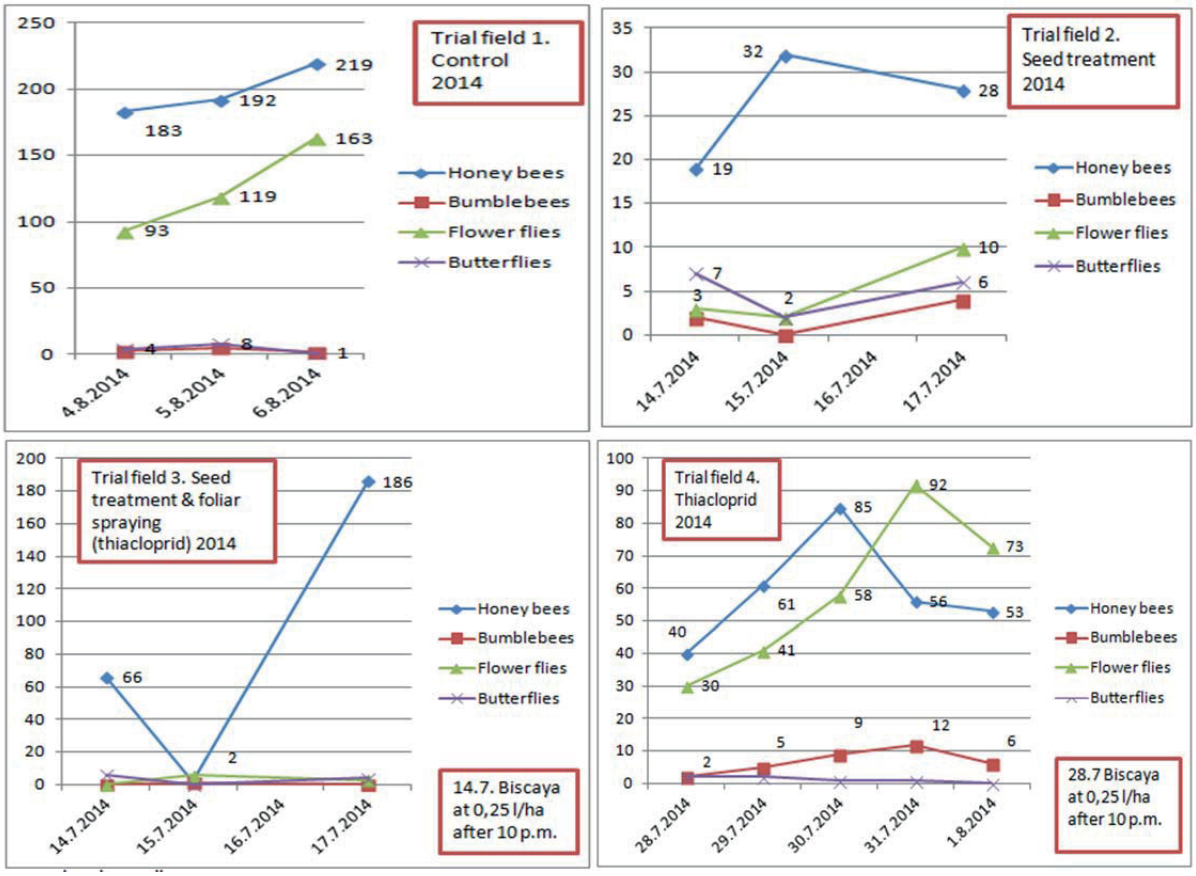

Figure 3. Number of honey bees, bumble bees, flower flies, and butterflies in the field study during the flowering of turnip rape in 2014.

4.3. Weather data in the trial sites between May 2013 and June 2015

The growing conditions in the growing season of 2013 were favourable to spring turnip rape. The mean temperatures of May, June and August were higher than normal, and by the end of August the effective temperature sum was 1284.6 °C, which is 165.8 °C higher than the long-term (1981-2010) average. May was dry, but the precipitation was approximately normal during the rest of the growing season, and the dry periods were rather short. No late spring frosts or early autumn frosts occurred.

The weather was warmer than normal in April 2014. May had several very warm days. However, some considerable falls of rain occurred in the Jokioinen area. June was cold and very rainy. Night frosts occured during three nights in June. The weather from July until mid-August was very warm and dry. The end of August was rainy (1981-2010). By the end of August, the effective temperature sum of 1231.2 °C was 112.4°C higher than the long-term sum (1981-2010). Detailed weather data from May 2013 until June 2015 is presented in Appendix 5.

4.4. Condition of honey bee colonies, number of honey bees and brood, bee colony development, annual results 2013 and 2014

The test bee colonies were inspected four times during the summer season of 2013 and once late in fall at the beginning of overwintering in 2013. The timing of the inspections during the summer was synchronized with the flowering rhythm of the test site vegetation. The first census was conducted between 25 June and 3 July, the second between 17 July and 19 July, the third between 31 July and 2 August, and the fourth between 16 August and 24 August depending on the growth stage on the test

field. The last census for all test hives was conducted on 28 October at the same time with the oxalic acid trickling. The colonies were inspected for the first time on 13 March after the cleansing flight in 2014. A detailed spring census of the test bee colonies was conducted from 22 April to 23 April. The timing of the inspections during the summer was synchronized with the flowering rhythm of the test site vegetation and the first census was conducted between 4 July and 7 July, the second between 17 July and 1 August, and the third on 26 August. Moreover, the trial site 1 and trial site 4 test colonies were inspected on 14 August and on 5 August respectively. The last census for all test hives was conducted on 4 December, 2014. The spring inspection was conducted on 25 March, 2015 and the final census on 11 May, 2015. The test bee hives were altogether carefully analysed 11-12 times alongside normal management during the two test years. The population development graphs of the test bee colonies are presented in Figures 4, 5, and 6 (2013) and in Figures 7, 8, and 9 (2014).

The number of bees and brood during the summer were statistically evaluated. The results of both years were analysed separately. The repeated factor in the model was measurement time. The model included a trial site and measurement time, and their interaction as fixed effects. A beehive was included in the model as a random factor. This model takes into account the possible correlation of measurements received from the same beehive. Before the statistical analysis, a square-root transformation was made. All presented estimates were transformed back to the original scale.

The number of bees between trial sites displays no statistically significant differences over the course of 2013 (Figure 4).

The profile of the adult bee population development curves is similar in both the control test field colonies and in the seed treatment test field colonies. All other curve profiles differ statistically from each other ($P<0.001$-0.04). The forest test site colonies display a distinctly different profile of the population development curve compared to the other test site colonies ($P<0.01$).

In the second census 17.7-19.7, the seed treatment + sprayed test field colonies have statistically significantly fewer bees than the forest test field colonies ($P=0.01$).

In the fourth census 16.8-24.8, the control test field colonies have statistically significantly more bees than the sprayed test field colonies ($P=0.01$) and almost statistically significantly more than in the forest test field colonies ($P=0.06$). Furthermore, the seed treatment test field colonies also have statistically significantly more bees than the sprayed test field colonies ($P<0.01$) and almost statistically significantly fewer than in the seed treatment + sprayed test field colonies ($P=0.10$). Additionally, the seed treatment + sprayed test field colonies have statistically significantly more bees than the sprayed test field colonies ($P<0.01$) and the forest test field colonies ($P=0.01$).

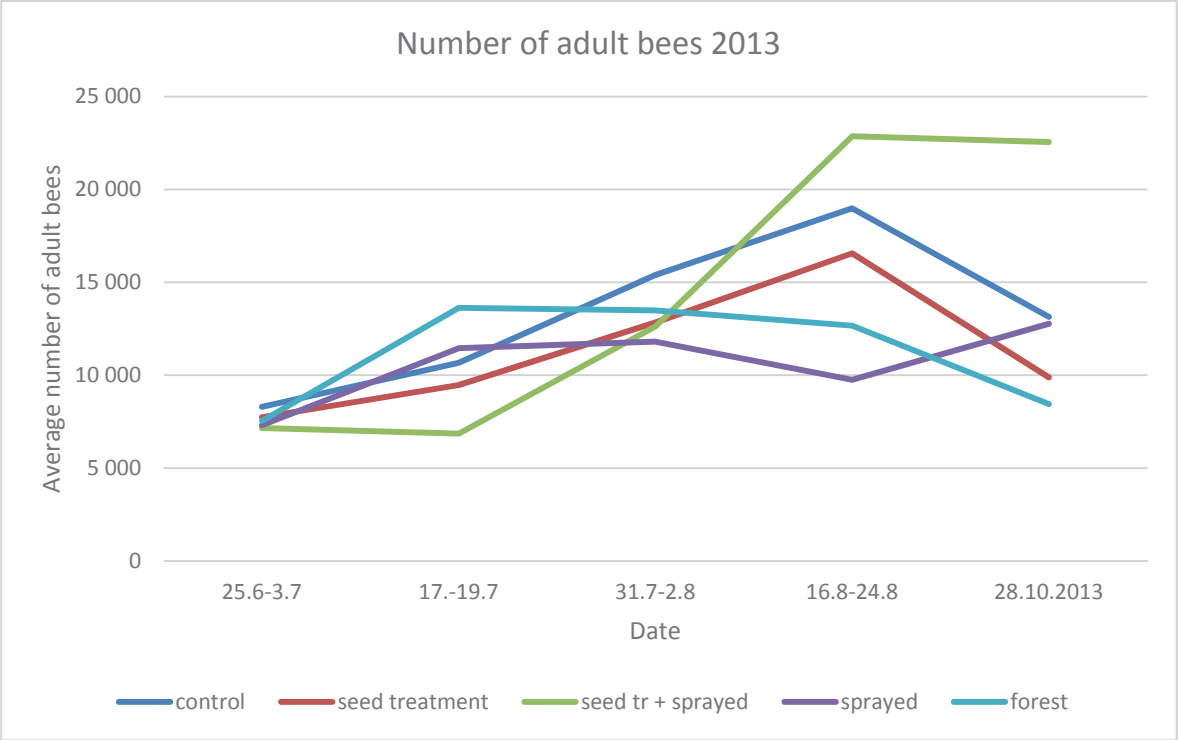

Figure 4. Average number of adult bees in the hives of each trial site in 2013.

In the fifth census of 28.10, the control test field colonies have statistically significantly more bees than the seed treatment test field colonies (P=0.04) and the forest test field colonies (P=0.01). Moreover, the seed treatment test field colonies have statistically significantly fewer bees than the seed treatment + sprayed test field colonies (P=0.001). Furthermore, the seed treatment + sprayed test field colonies have statistically significantly more bees than the sprayed test field colonies (P<0.01) and forest test field colonies (P<0.01), which also have statistically significantly fewer bees than the sprayed test field colonies (P<0.01).

The profile of the brood population development curves in 2013 is similar in the control test field colonies and seed treatment test field colonies (Figure 5). The forest test field colonies' brood population development curve profile is also similar to the control test field colonies. The other brood population development curve profiles, however, display statistically significant differences in comparison to each other (P=0.04).

There are statistically significant differences in the number of brood between the trial sites over time (P=0.03). The seed treatment + sprayed test field colonies' curve is on a significantly higher level than the curves of the seed treatment test field colonies (P=0.02), sprayed test field colonies (P<0.01), and forest test field colonies (P=0.02). The control test field colonies' curve is also almost on a significantly higher level (P=0.07) in comparison to the sprayed test field colonies' curve.

In the first census 25.6-3.7, the control test field colonies have statistically significantly more brood than the sprayed test field colonies (P=0.02). The forest test field colonies have significantly more brood than the seed treatment (P=0.04) and seed treatment + sprayed test field colonies (P<0.001). The seed treatment + sprayed test field colonies have almost statistically significantly more brood than sprayed test field colonies (P=0.07).

In the second census 17.7-19.7, the control test field colonies have statistically significantly more brood than the seed treatment + sprayed (P=0.04) and sprayed test field colonies (P=0.03).

In the third census 31.7-2.8, the control test field colonies have almost statistically significantly fewer brood than the seed treatment + sprayed (P=0.08) and sprayed test field colonies (P=0.08). The seed treatment test field colonies have significantly more brood than the sprayed test field colonies (P=0.05) and almost significantly more than the forest test field colonies (P=0.09). The seed treat-

ment + sprayed test field colonies have statistically significantly more brood than the sprayed test field colonies (P<0.01) and forest test field colonies (P=0.01).

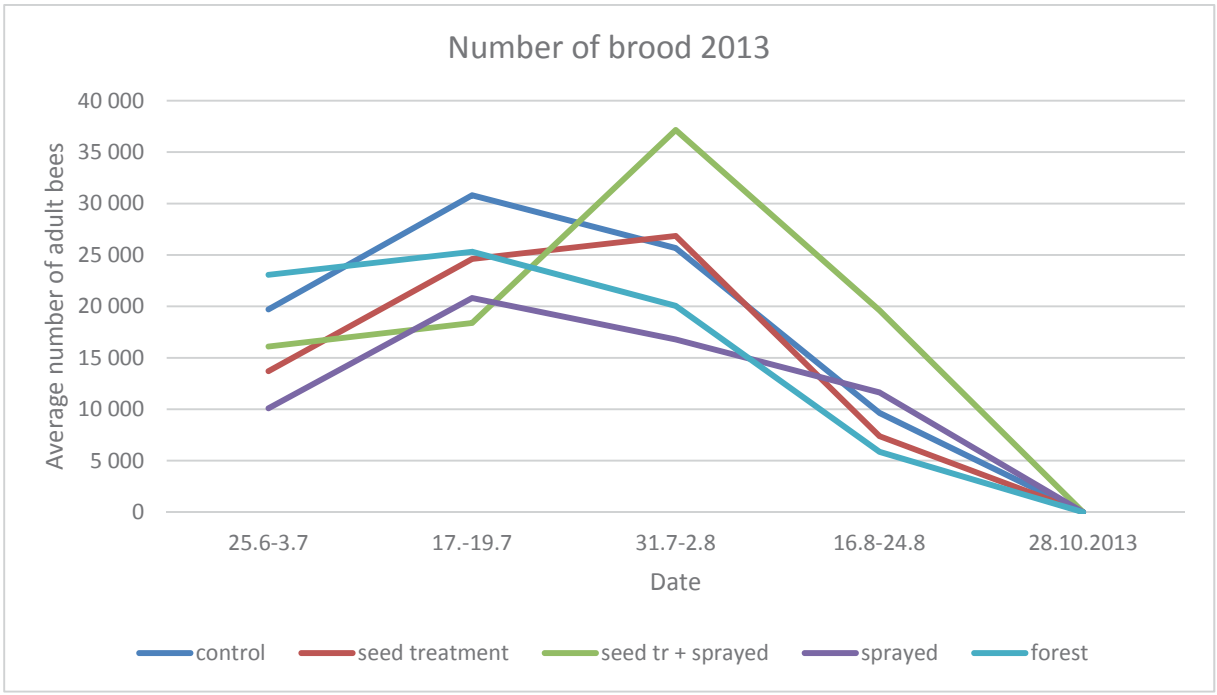

Figure 5. Average number of brood in the hives of each trial site in 2013.

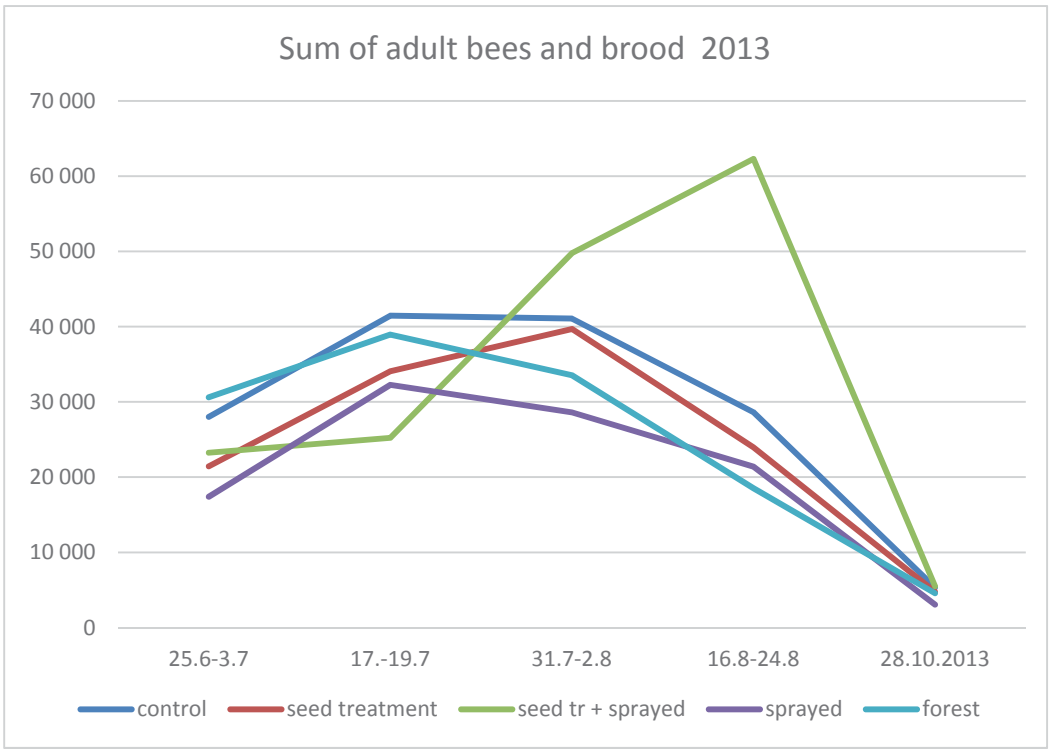

Figure 6. Average number of adult bees and brood in the hives of each trial sites in 2013.

During the fourth census 16.8-24.8, the seed treatment + sprayed colonies have significantly more brood than all other test field colonies (P<0.01). The sprayed test field colonies also have almost statistically significantly more brood than the forest test field colonies (P<0.07).

The sum profile of the adult bees and brood population development curves in 2013 is similar in the control test field colonies, seed treatment test field colonies, and forest test field colonies (Figure 6). Additionally, the sum profile of the adult bees and brood population development curves is almost notably different in the control test field colonies and in the sprayed test field colonies (P=0.06).

There are significant differences in the number of adult bees and brood between the trial sites over time (P<0.01). The control test field colonies have a significantly higher number of adult bees and brood than the sprayed test field colonies over time (P<0.02). The number of adult bees and brood is significantly higher over time in the seed treated + sprayed test field colonies than in the seed treated test field colonies (P=0.02), spayed test field colonies (<0.01), and forest test field colonies (P<0.01). Moreover, the number of adult bees and brood is almost statistically significantly higher over time in the seed treated test field colonies than in the sprayed test field colonies (P=0.08).

In the first census 25.6-3.7, the number of adult bees and brood is significantly higher in the control test field colonies than in the sprayed test field colonies (P<0.01). The seed treatment test field colonies have almost statistically significantly more adult bees and brood than the sprayed test field colonies (P=0.06). The seed treatment + sprayed test field colonies have significantly more adult bees and brood than the sprayed test field colonies (P<0.01) and the sprayed test field colonies have statistically significantly fewer adult bees and brood than the forest test field colonies (P<0.01).

In the second census 17-19.7, the number of adult bees and brood is significantly higher in the control test field colonies than in the sprayed test field colonies (P<0.01). The seed treatment test field colonies have almost significantly more adult bees and brood than the sprayed test field colonies (P=0.10). The seed treatment + sprayed test field colonies have fewer adult bees and brood than the sprayed test field colonies (P<0.07).

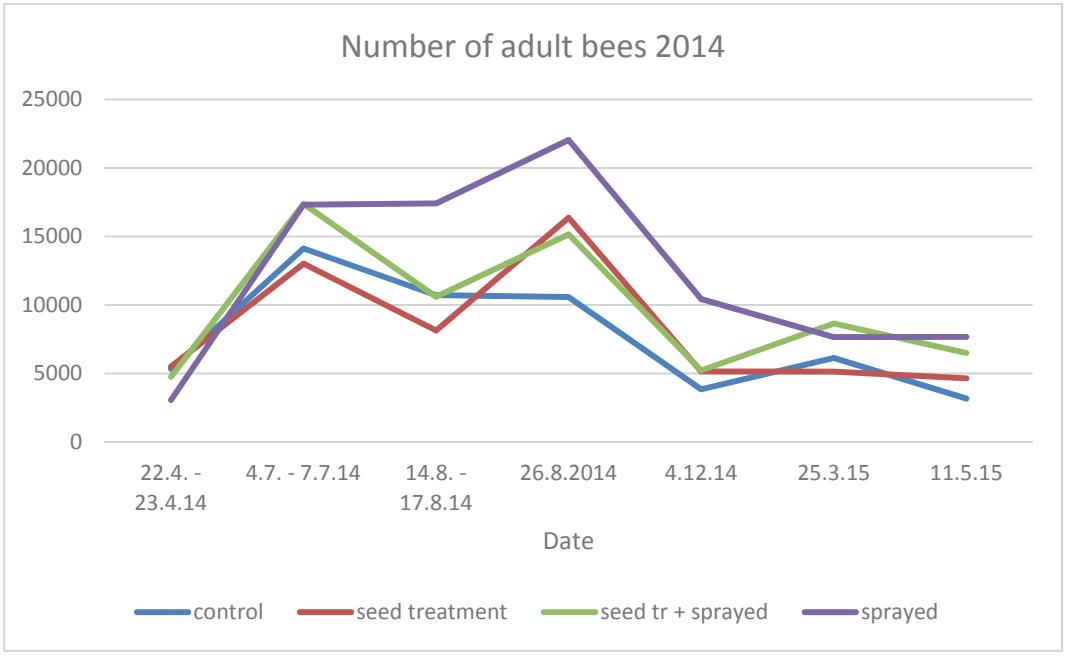

Figure 7. Average number of adult bees in the hives of each trial site in 2014

In the third census 31.7-2.8, the number of adult bees and brood is statistically significantly higher in the control test field colonies than in the sprayed test field colonies (P=0.02) and almost statistically significantly lower than in the seed treatment + sprayed test field colonies (P=0.09). The seed treatment test field colonies have statistically significantly more adult bees and brood than the sprayed test field colonies (P=0.06). The seed treatment + sprayed test field colonies have statistically significantly more adult bees and brood than the seed treatment, sprayed, and forest test field colonies (P<0.01).

The profile of the adult bee population development curves in 2014 is significantly different between the control and sprayed test field colonies (P<0.01) and between the seed treatment + sprayed test field colonies and sprayed test field colonies (P<0.01) (Figure 7). In addition, the seed treatment test field colonies have a different adult bee development curve than the sprayed test field colonies (P=0.07). The result is nearly statistically significantly different.

There are no statistically significant differences between the trial sites over time in the number of bees 2014.

In the first census 22.4-23.4, the sprayed test field colonies have fewer bees than the seed treatment + sprayed (P=0.08) and control test field colonies (P=0.09).

In the third census 14.8-17.8, the sprayed test field colonies have statistically significantly more bees than the seed treatment and control field colonies (P=0.01) and nearly statistically significantly more bees than the seed treatment + sprayed test field colonies (P=0.10).

On 26.8, the sprayed test field colonies have significantly more bees than the control test field colonies (P=0.01)

On 4.12, the sprayed test field colonies still have significantly more bees than the control (P=0.05) and seed treatment + sprayed (P=0.02) test field colonies.

In spring, after overwintering, on 11.5.2015, the control test field colonies have almost statistically significantly fewer bees than the sprayed test field colonies (P=0.09).

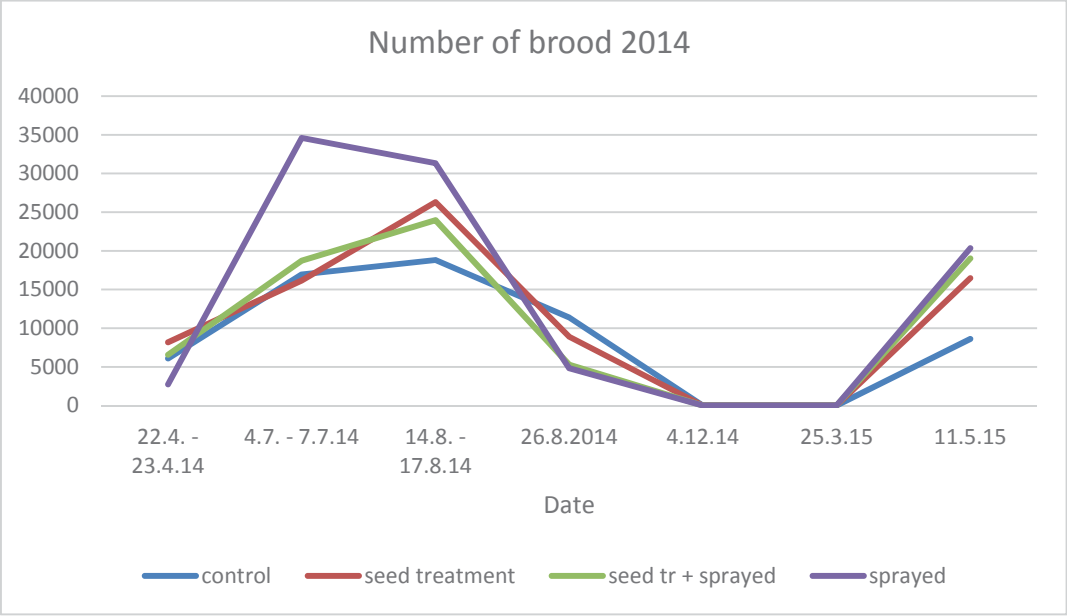

Figure 8. Average number of brood bees in the hives of each trial sites 2014-2015

The profile of the brood population development in the sprayed test field colonies is significantly different from the control test field colonies (P<0.01) and seed treatment + spraying test field colonies (P=0.03) in 2014 (Figure 8).

There are no statistically significant differences between the trial sites over time in the number of brood in 2014.

In the first census 22.4-23.4, the sprayed test field colonies have statistically significantly fewer brood than the control test field colonies (P=0.05).

In the second and third censuses 4.7-7.7 and 14.8-17.8, the sprayed test field colonies have statsitically significantly more brood than all other test field colonies (P=0.01-0.05 and 0.02-0.05 respectively).

In the fourth census of 26.8, the sprayed test field colonies have nearly significantly fewer brood than the control test field colonies (P=0.08). Furthermore, the seed treatment test field colonies have nearly statistically significantly fewer brood than the control test field colonies (P=0.10).

In spring, after overwintering, on 11.5.2015, the control test field colonies have significantly fewer brood than the sprayed test field colonies (P=0.09) and nearly statistically significantly fewer than the seed treatment + sprayed test field colonies (P=0.06).

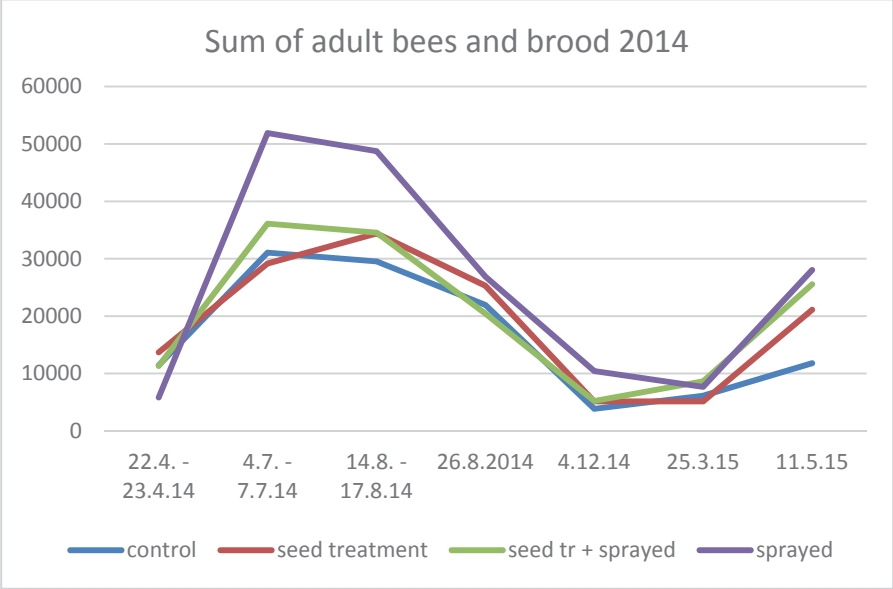

Figure 9. Average number of adult bees and brood in the hives of each trial sites 2014-2015

The profile of the adult bee and brood population development graph of the sprayed test field colonies differs statistically significantly from all other population graphs' profiles over time (control test field colonies P=0.001, seed treatment test field colonies P=0.04, seed treatment + sprayed P=0.01) in 2014 (Figure 9). There are no significant statistical differences between the trial sites over time in the sum of bees and brood.

In the first census 22.4-23.4, the sprayed test field colonies have statistically significantly fewer bees and brood than the control test field colonies (P=0.01) and seed treatment + sprayed test field colonies (P=0.04).

In the second census 4.7-7.7, the sprayed test field colonies have statistically significantly more bees and brood than the control test field colonies (P=0.03) and seed treatment + sprayed colonies (P=0.02).

From 14.8 to 17.8, the sprayed test field colonies have statistically significantly more bees and brood than all other test field colonies (control test field colonies P=0.01, seed treatment test field colonies P=0.04, seed treatment + sprayed 0.01).

In the fourth census of 26.8, the test field colonies have no statistical differences. In spring, after overwintering, on 11.5.2015, the control test field colonies have significantly fewer bees and brood than the sprayed test field colonies (P=0.01) and nearly significantly fewer than the seed treatment + sprayed test field colonies (P=0.06).

The spring census in 2014 was performed between 22 and 23 April when the bees had completed the first cleansing flights after overwintering. Two of the inspected bee hives were lost during fall and winter. These were hive number 3 from trial site 1 and hive number 5 from trial site 2. Both hives lost their queen. Taking everything into account, the winter losses in the field study of spring 2014 do not differ from the average winter losses of 10 % in the whole of Finland.

A one-way ANOVA was used to test food consumption variables and the differences between trial sites at OWI. The distribution of OWI was skew and a $\log_e$-transformation was made before statistical analysis.

The average range of food consumption during overwintering 2013-2014, then, was 14-18 kg per beehive on each trial site (Figure 10). This level of food consumption is typical for normal bee colo-

nies in South-West Finland. There are no significant differences in food consumption during winter 2013-2014, but the difference between the control and seed treatment + sprayed test field colonies is almost significant (P=0.09). The average range of food consumption during overwintering 2014-2015 was 10-13 kg per beehive on each trial site (Figure 11) and there were no statistical differences between the trial sites.

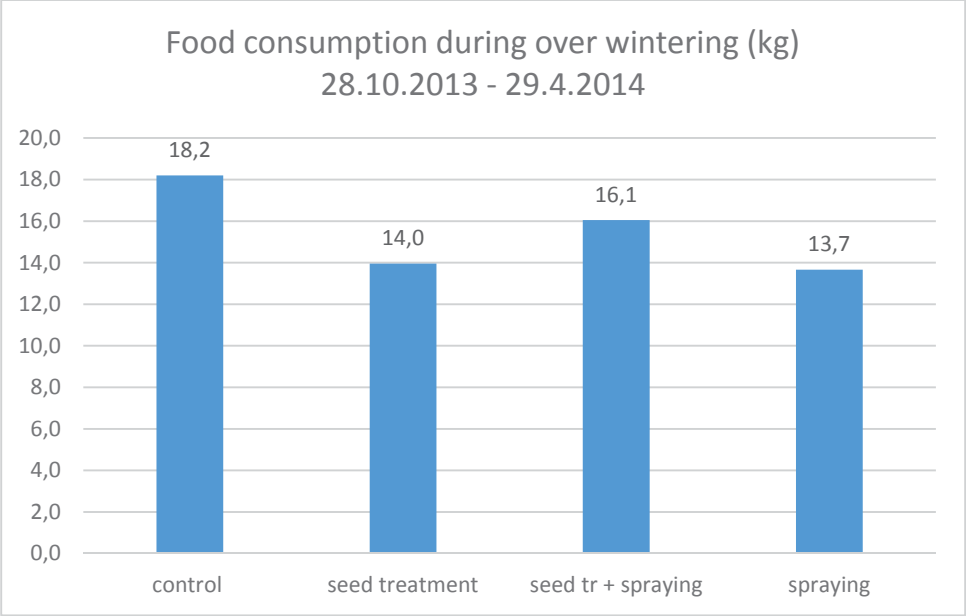

Figure 10. Average food consumption during overwintering 2013-2014. The measuring period consisted of 183 days and the average daily food consumption in the different test sites was 99.5 g, 76.3 g, 87.7 g, and 74.7 g per day per colony respectively.

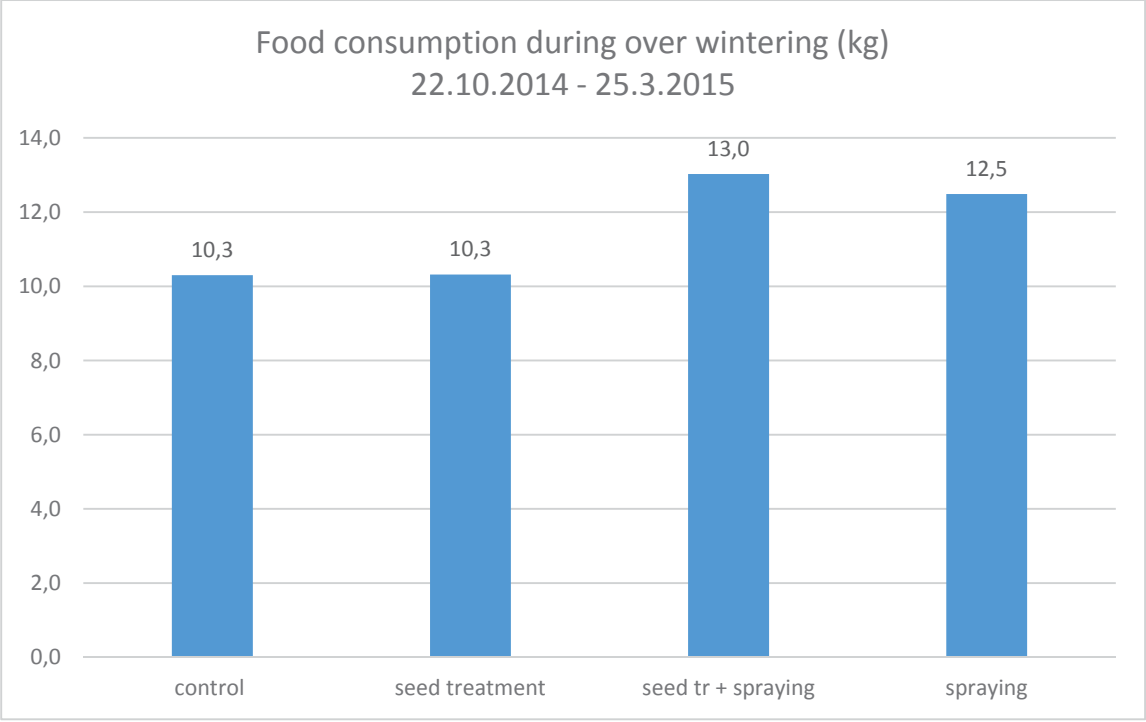

Figure 11. Average food consumption during overwintering 2014-2015. The measuring period consisted of 154 days and the average daily food consumption in the different test sites was 84.4 g, 67.0 g, 84.6 g, and 74.2 g per day per colony respectively.

The Overwintering Index (OWI) describes the relation of adult bees in spring in comparison to the number of adult bees in the beginning of overwintering. This, in turn, indicates a possible weakening of the colony during fall. Figures 11 and 14 present the average overwintering indexes on all trial sites. The average of the OWI in the researched areas ranges from 0.3 to 0.8 (2013) and from 0.82-1.27 (2014). The spring evaluation was performed when the number of adult bees was at its lowest and when the brood rearing had begun. There were no statistically significant differences in the OWI between the test sites either.

All statistical analyses were made using the SAS/MIXED procedure, version 9.3. After an analysis, a box-plot of residuals, a scatter plot of residuals and fitted values were utilised to detect unequal error variances and outliers.

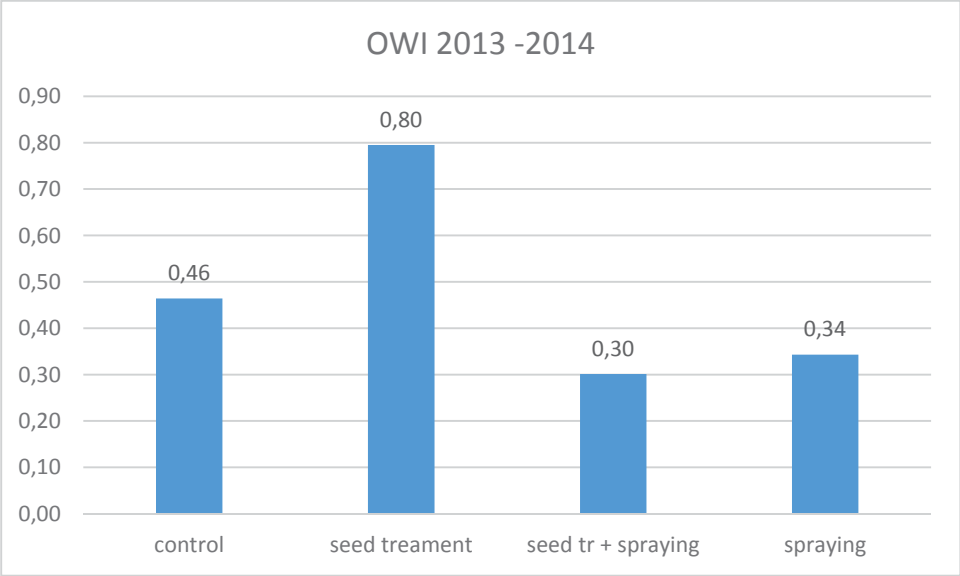

Figure 12. Average overwintering indexes 2013-2014

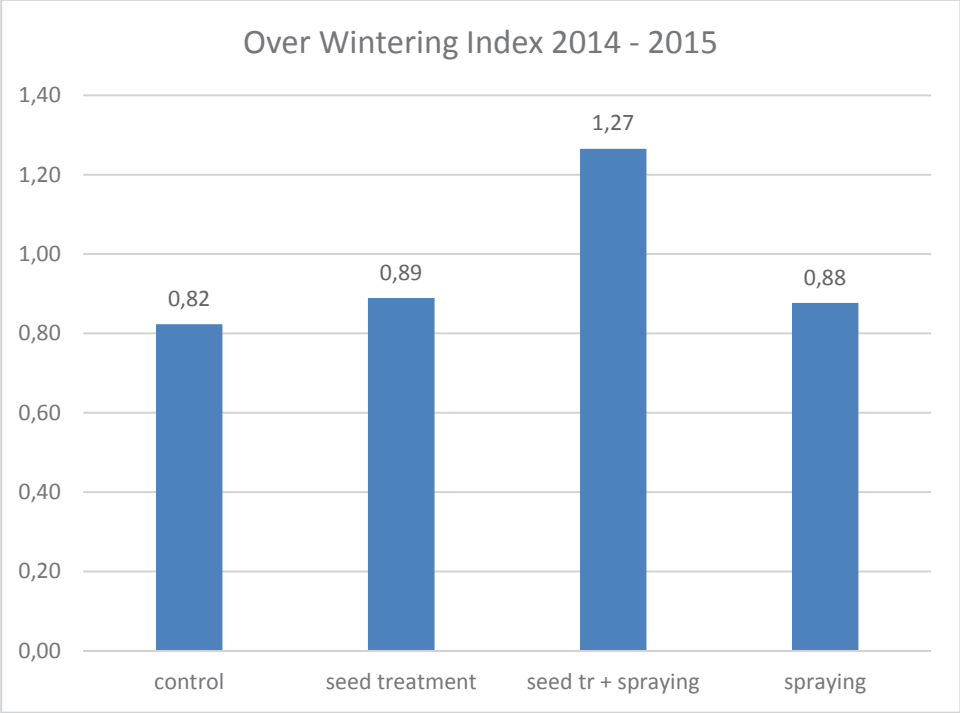

Figure 13. Overwintering indexes 2014-2015.

4.5. The origin of honey, pollen loads, and bee bread in trial sites

Tables 4 and 5 present the average content of the *Brassica* pollen in pollen loads, bee bread, nectar, and honey samples. The results indicate that bees have visited and gained yield from *Brassica* strongly in 2013 but alternatingly in 2014.

Table 4. Average content of Brassica pollen grains in the beecolonies at trial sites in 2013.

	Average content of Brassica pollen grains in samples 2013 (% sd)			
	Pollen loads	**Perga**	**Nectar**	**Honey**
Trial site 1	81.39 (±9.84)	84.7	58.98 (±31.30)	82.6 (±10.68)
Trial site 2	88.69 (±14.95)	86.3	79.1 (±14.26)	69.93 (±1.77)
Trial site 3	40.17 (±20.23)	48.6 (±19.37)	67.5 (±13.54)	65.46 (±16.44)
Trial site 4	72.36 (±17.55)	36.65 (±7.71)	53.92 (±14.08)	43.6 (±33.98)

Table 5. Average content of Brassica pollen grains in the beecolonies at trial sites in 2014.

	2014 Average content of Brassica pollen grains in samples 2014 (% sd)			
	Pollen loads	**Perga**	**Nectar**	**Honey**
Trial site 1		1/8 10.9 (±10.94) 14/8 82.2 (±19.16)	26.6 (±35.9)	1.6 (±0.8)
Trial site 2	40.9 (±5.97)	44.6 (±14.92)	37.7 (±32.6)	52.4 (±41.6)
Trial site 3	26.3(±7.7)	41.9 (±45.32)	65.8 (±18.6)	48.2 (±37.5)
Trial site 4	4.6 (±6.3)	24/7 8.0 (±8.65) 5/8 14.2 (±6.39)	7.5 (±18.8)	18.3 (±26.7)

4.6. Residue analysis

All neonicotinoids (thiametoxam, tiacloprid, acetamiprid, imidacloprid, clotianidin) approved in Finland were monitored in the project samples. In addition, two metabolites (6-cloronicotinic acid, acetamiprid-N-deshmethyl), other pesticides that were applied to the trial sites (Metyalaxyl-M, Fludioxonil, Esfenvalerate, Deltamethrin), and other relevant pesticides (Tau-fluvalinate, Lambda-cyhalothrin, Prochloraz, Iprodione, Axozystrobin) commonly used for oilseed cultivation in Finland were monitored (Table 6).

Table 6. Compounds monitored in bee hive and bee samples.

Compound	Detection	LOQ, nectar (ng/g) LOD in parenthesis	LOQ, bee bread (ng/g)
Thiametoxam	LC-MS/MS	0.05	0.1
Thiacloprid	LC-MS/MS	0.05	0.1
Clothianidin	LC-MS/MS	0.05	0.1
Acetamiprid	LC-MS/MS	0.05	0.1
Imidacloprid	LC-MS/MS	0.05	0.1
6-Chloronicotinic acid	LC-MS/MS	7.5 (LOD=1 ng/g)	15
Acetamiprid-N-deshmethyl	LC-MS/MS	0.05	0.1
Metalaxyl-M	LC-MS/MS	0.05	0.1
Fludioxonil	LC-MS/MS	5 (LOD=1 ng/g)	10
Esfenvalerate	GC-MS/MS	5 (LOD=1 ng/g)	10
Deltamethrin	GC-MS/MS	5 (LOD=1 ng/g)	10
Tau-fluvalinate	GC-MS/MS	15 (LOD=5 ng/g)	30
Lambda-cyhalothrin	GC-MS/MS	5 (LOD=1 ng/g)	10
Prochloraz	GC-MS/MS	15 (LOD=5 ng/g)	30
Iprodione	GC-MS/MS	7.5 (LOD=1 ng/g)	15
Azoxystrobin	GC-MS/MS	5 (LOD=1 ng/g)	10

4.6.1. Analytical methods

Analytical methods were developed for the determination of pesticide residue levels in honey, bee bread, pollen, bees, and turnip rape flowers. The methods were based on QuEChERS (Quick, Easy, Cheap, Effective, Rugged, Safe) sample preparation originally introduced by Anastassiades et al 2003. The analytes were detected with liquid chromatography tandem mass spectrometry (UPLC-MS/MS) or gas chromatography tandem mass spectrometry (GC-MS/MS) (Table 6). No pretreatment was necessary for the pollen samples, whereas the honey samples were heated by less than 35 ^{o}C in a water bath. The bee bread was ground in a mortar before the extraction, whereas the bees were lyophilised and ground as a pretreatment. The turnip rape flowers were freeze-dried and homogenised in a small laboratory mill before the analysis. The compounds were extracted with a water-acetonitrile mixture by dispersive solid phase extraction (dSPE). The resulting extract from the hive samples was further cleaned with primary and secondary amine (PSA) and octadecyl silane (C18) absorbents. Plant samples were cleaned with PSA and carbon (ENVI-Carb) absorbents in order to remove plant pigments. Extra purification steps, freezing out, and washing of the supernatant with hexane were applied for the bee and bee bread matrices. Part of the clean extract was concentrated by evaporation, reconstituted to methanol-water, and filtered for the UPLC-MS/MS analysis. For the GC-MS/MS analysis, part of the clean extract was reconstituted to acetone.

The UPLC-MS/MS analyses were performed on a Waters Acquity UPLC coupled with a Waters Xevo TQMS triple quadrupole tandem mass spectrometry. The chromatographic separation was performed on a Waters Acquity BEH C18 column (1.7 µm, 2.1 mm x 100 mm) equipped with a precolumn (Waters, VanGuard). Electron spray ionization (ESI) operating on positive mode was used on the mass spectrometric analysis. For each analyte, at least two MRM transitions were measured.

The GC-MS/MS analyses were performed on a Thermo Trace GC Ultra and TriPlus RSH autosampler coupled with a TSQ Quantum XLS triple quadrupole tandem mass spectrometry. The ionization technique was EI. The chromatographic separation was performed on a Phenomenex Zebron ZB-50 column (0.25µm, 30 m x 0.25 mm) equipped with a Phenomenex Zebron HT-deactivated precolumn (10 m x 0.53 mm). A backflush of precolun was used for increasing the lifetime of the analytical column. For each analyte, at least two MRM transitions were measured.

The analytical methods for bees and hive products were validated based on DG Sanco guidance (DG Sanco 12571/2013). Procedural standard calibration was used in the quantification of the compounds. Moreover, deuterated internal standards were used for the quantification of the thiametoxam and clotianidin. The limit of quantification (LOQ) was determined to be the lowest standard point. The LOQs for the residues are shown in Table 6.

Matrix-matched calibration was used for the analysis of the flowers for thiametoxam and clothianidin: The quantitative areas were 0.25-35 ng/g as dry weight. The separate calibration for thiacloprid was necessary, because concentrations of thiacloprid were very high in some flower samples: In 2013, different amounts of thiacloprid were added in blank flower extracts, with a quantitative area of 0.25-50 µg/g (as dry weight). The thiacloprid results have been confirmed with recovery tests (recovery 93-100%). Matrix-matched calibration was also used for thiacloprid in 2014. The flower samples from 2013 were re-analysed with Matrix-matched calibration in 2014.

4.6.2. Residues of neonicotinoids in turnip rape flowers in the field study

Three neonicotinoids (clothianidin, thiacloprid, thiametoxam) that were applied in the trial sites were analysed from the flower samples. The residue amounts of clothianidin + thiametoxam in the samples collected from trial fields 2 and 3 and the residue amounts of thiacloprid in the samples from trial fields 3 and 4 are presented in Figures 14-16. Seed treatment was used in trial fields 2 and 3 and foliar sprayings with neonicotinoids were performed in trial fields 3 and 4. The sum concentrations of clothianidin + thiametoxam varied between the different sampling points from 4 to 51 ng/g and the differences between the fields were significant. The concentration of thiacloprid was similar in both trial fields immediately after spraying, the concentration being 29.5 µg/g at most. After the spraying, the amounts of thiacloprid decreased logically.

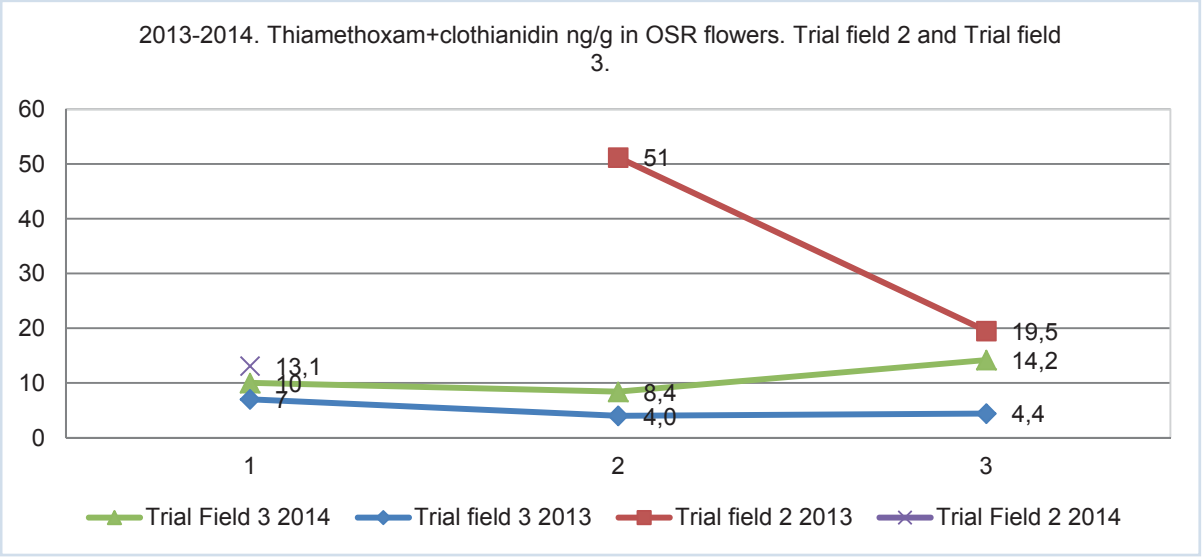

Figure 14. Residues of neonicotinoids in turnip rape flowers in 2013 and 2014.

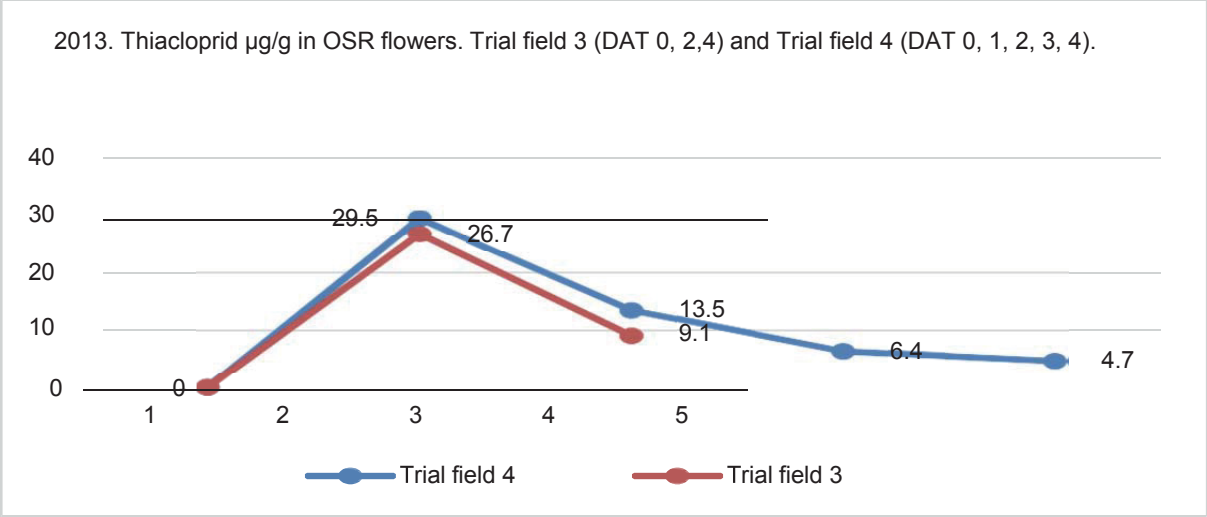

Figure 15. Residues of neonicotinoids in turnip rape flowers in 2013. The concentrations are in dry-weight.

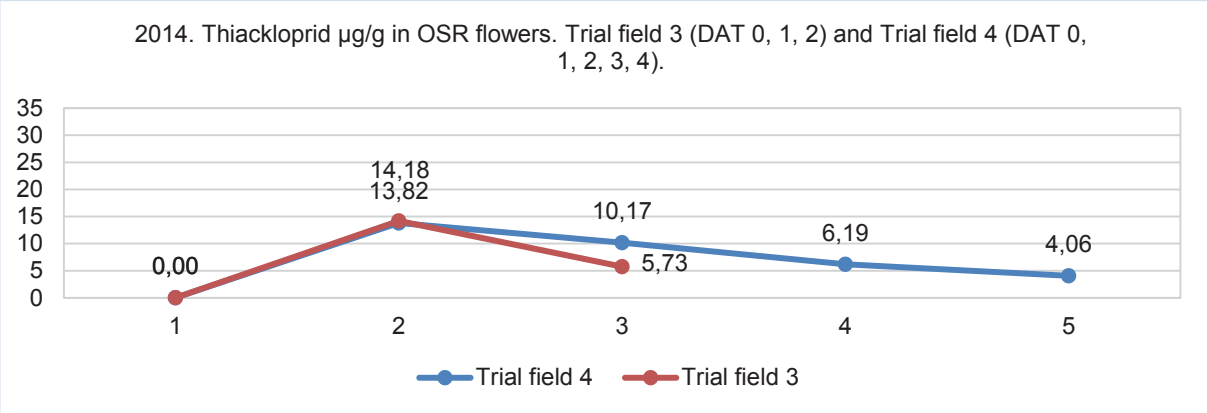

Figure 16. Residues of neonicotinoids in turnip rape flowers in 2014. The concentrations are in dry-weight

4.6.3. Residues in the honey bee colonies (nectar, honey, bee bread, pollen, worker honey bees)

Residues of thiametoxam and chlothianidin (seed treatment neonicotinoids)

Thiametoxam was applied to trial sites 2 and 3 in both growing seasons in 2013 and 2014. Clothianidin is the main metabolite of thiametoxam and as such, residues of both thiametoxam and clothianidin were expected to appear in the samples. The residues were measured in all types of hive samples including nectar (from the comb near brood), honey, bee bread (from the comb near brood), and pollen (from the legs of the worker bees). In this report, residues of thiametoxam and clothianidin are mainly presented as a sum of concentrations ($c_{thia+clo}$), which is a relevant procedure because thiametoxam and clothianidin possess a similar mechanism of action, toxicity, and similar LD_{50} values.

Residues of clothianidin and thiametoxam in the field study (Part A)

The sampling in all trial sites failed in 2013 because turnip rape flowering was already over when the nectar and bee bread samples were collected in the trial sites in mid-June. Then again, other oilseed

fields were still flowering in same area in South-West Finland. The sampling in trial sites 1 and 4 in 2014 failed as well because when the sampling was performed at the end of July or at the beginning of August and at the end of August, the flowering had not fully begun or it was over. Therefore, the residue results are not comparable to the neonicotinoid treatments of the fields or to the condition of the bee hives. In 2013, seed treatment neonicotinoids were detected in all samples even though the trial field was not treated with thiametoxam (Figure 17, Table 7). The highest concentration, 4.45 ng/g, was found in the field where no neonicotinoids had been used. The results of the analysis of the pollen's origin in nectar and bee bread in 2013 (Table 4) demonstrated that bees from all trial sites foraged primarily to the oilseed fields. The conclusion is supported by the fact that there was other oilseed cultivation within a distance of less than two kilometres from the trial site (Appendix 3). In 2014, the location of other oilseed crops was also closer than three kilometres from the test fields. In 2014, residues were mostly discovered in the samples from the trial sites that were treated with thiametoxam. One expection was hive number 2 in trial site 1 (no neonicotinoids). However, the residue results from sites 1 and 4 are not comparable, since the sampling did not occur during flowering. The analysis of the pollen's origin displayed that the low proportion of pollen in the nectar samples collected from trial sites 1 and 4 was derived from oilseed crops. The content of Brassica pollen in nectar (corresponding samples for which residue data is displayed in Figure 17) was 17.9%, 1.3%, 89.8%, 8.7%, and 15.6% in samples from site 1 and 4.9%, 8.9%, 1.2%, 29.5%, and 5.3% in samples from site 4 (Table 5). In general, the residue levels of seed treatment neonicotinoids were somewhat higher in the nectar samples of 2013 than in the samples of 2014. Both clothianidin and thiametoxam were detected in the samples. The sum of the concentrations of thiametoxam and clothianidin ($c_{thia+clo}$) in nectar were between 0.05 and 4.45 ng/g and 0.0 and 0.99 ng/g respectively in 2013 and 2014. In particular, the residue levels of chlothianidin were, for the most part, higher in 2013. The average concentration of clothianidin and the standard deviation in all positive nectar samples was 0.42±0.43 ng/g in 2013, whereas it was as low as 0.06±0.02 ng/g in 2014. Clothianidin is the main metabolite of thiametoxam in plants. Therefore, it was expected that both compounds would appear in the samples. However, the relative concentration of clothianidin versus thiametoxam varied between hive samples. Clothianidin was as commonly used a seed treatment neonicotinoid as thiametoxam in the growing season of 2013 in Finland. We suspect that in 2013, bees from trial site 2 have foraged on a more attractive oilseed field that was treated with clotianidin. This could explain the high relative clothianidin concentrations in the hive samples from trial site 2 in 2013. The level of thiametoxam was similar in the nectar samples of both years. The average concentration of thiametoxam was 0.54±0.98 ng/g in 2013 and 0.36±0.30 ng/g in 2014.

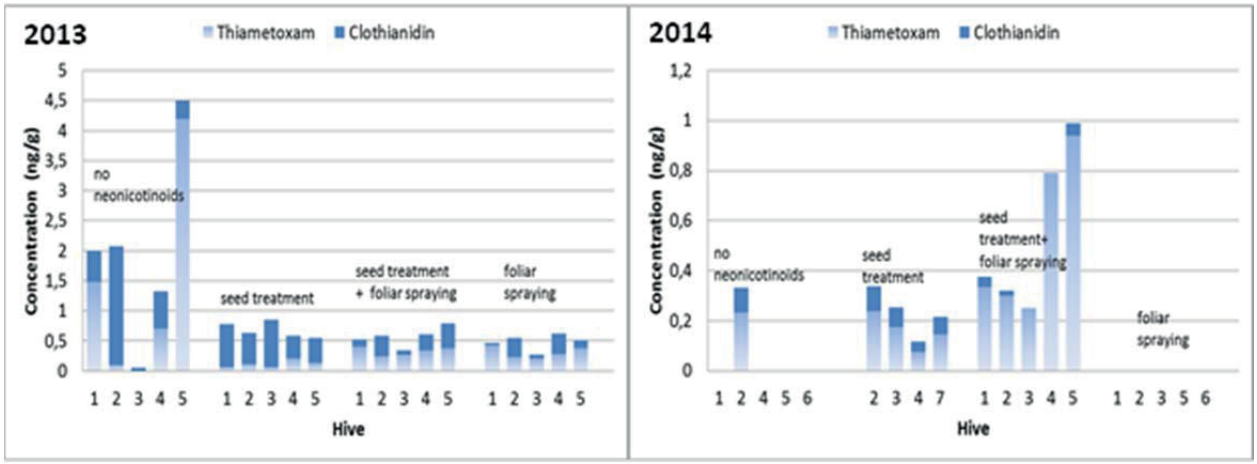

Figure 17. Field study. Residues of thiametoxam and clothianidin in nectar collected from hives in 2013 and 2014. Site 1: no neonicotinoids, Site 2: seed treatment, Site 3: seed treatment+foliar spraying Site 4: foliar spraying.

Table 7. Residues of thiametoxam and clothianidin in nectar, honey and bee bread in 2013 and 2014. n=number of samples in which residues were ≥ log.

Sample	Year	Number of positive samples/Total number of samples	Average concentration of thiametoxam (ng/g) ± sd n=20	Average concentration of clothianidin (ng/g) ± sd n=7-9
nectar	2013	20/20 (Thiametoxam) 20/20 (Clothianidin)	0.80 ± 0,84	0,41 ± 0,43
honey	2013	20/20 (Thiametoxam) 20/20 (Clothianidin)	0,54 ± 0,94	0,77 ± 0,62
bee bread	2013	15/17 (Thiametoxam) 14/17 (Clothianidin)	0,45 ± 0,32	0,69 ± 0,45
nectar	2014	9/19(Thiametoxam) 6/19 (Clothianidin)	0,36 ± 0,3	0,06 ± 0,02
honey	2014	9/19(Thiametoxam) 7/19 (Clothianidin)	0,29 ± 0,2	0,07 ± 0,03
bee bread	2014	9/19(Thiametoxam) 14/19 (Clothianidin)	0,57 ± 0,69	0,13 ± 0,14

The honey samples were collected from hives in August 3-4 weeks after the end of flowering. The concentrations of thiametoxam and clothianidin in the honey samples were at the same level as in the corresponding nectar samples collected from the comb near the brood area. Similar to the nectar and honey samples, the bee bread samples from test sites 1 and 4 in 2013 contained residues of thiametoxam and clothianidin even though no neonicotinoids were used for seed treatment. Correspondingly, the bee bread samples of 2014 were consistent with the nectar samples. Residues were only detected in the samples that were collected from the field with seed treatment.

Table 8 displays the residues of thiametoxam and clothianidin in the pollen collected by pollen traps from the posterior legs of worker bees as they were entering the hives. The pollen samples were collected on 1-6 different days during flowering. The amount of the pollen sample varied from < 0.1 g to several dozens of grams depending on both the hive and the sampling day. The sample size was often insufficient for analysis. As such, the samples from different days were either combined for residue analyses or the analyses were not conducted. This variance in the representativeness of the samples must be taken into consideration when assessing the results. The concentration of seed treatment neonicotinoids in the pollen is definitely higher in the samples of 2013 compared to samples from 2014. The residue levels in the pollen are not comparable to the findings in the nectar (Figures 17), as the pollen was collected when the trial field was flowering, which was not true for all nectar samples.

Table 8. Residues of thiametoxam and clothianidin in pollen in the field study.

Neonicotinoid treatment of field	Year	Number of hives	Average sum concentration thiametoxam+ clothianidin (ng/g)	Max sum concentration thiametoxam+clothianidin (ng/g)
no neonicotinoid use	2013	2	≤0.1	0.4
seed treatment	2013	2	3.0	4.1
seed treatment and foliar spraying	2013	2	0.8	3.0
foliar spraying	2013	1	3.0	8.6
no neonicitinoid use	2014		na	na
seed treatment	2014	4	0.2	1.0
seed treatment and foliar spraying	2014	5	0.2	0.4
foliar spraying	2014	5	0	0

Residues of clothianidin and thiametoxam in the epidemiolocigal study (Part B)

In Part B of the project, the nectar and bee bread samples were collected as a sample survey. In 2013, the samples were collected from one geographical area in South-West Finland. The number of apiraries was 18 and the number of hives was 37. Figure 18 a) displays the residues of thiametoxam and clothianidin in the nectar samples that were collected from hives that were located close to the fields (<2.6km). The average $c_{thia+clo}$ and the standard deviation of the results from nine apiaries was 2.75±1.45 ng/g.The highest measured concentration $c_{thia+clo}$ was 5.67 ng/g. Figure 18 b) displays the residues of thiametoxam and clothianidin in the nectar samples collected from the hives that were situated far from oilseed fields (<2.7km). The concentrations were between 0-1 ng/g, with the exception of one apiary in which $c_{thia+clo}$ was 3.5 ng/g at its highest.

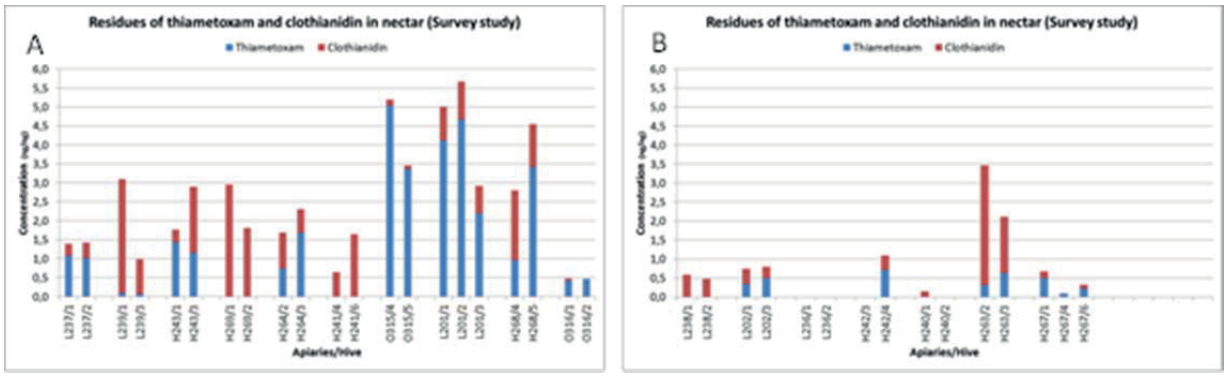

Figure 18 a) Residues of thiametoxam and clothianidin in nectar from hives which were located close to oilseed fields. O316 was located close to the organic field. **b**) Residues of thiametoxam and clothianidin in nectar from hives which were located far from oilseed fields.

Significantly more samples were collected in 2014 than in 2013 and from five different geographical areas, including areas where oilseed was not cultivated as much (Figure 19). Figure 19 displays the residue results of thiametoxam and clothianidin in nectar for 82 apiaries. Each result is an average concentration based on 1-3 hives, the total number of hives being 202. Seed treatment neonicotinoids were detected in samples from 49 apiaries. Positive apiaries were located in all areas. Despite the fact that the low detection limit of the method allows for the detection of very low concentrations, the prevalence of residues of seed treatment neonicotinoids in the hives is significant. The sampling was not optimised, for instance, for the time when the oilseed crop was flowering. The level of the residues is similar to the samples of 2013. The highest measured sum concentration $c_{thia+clo}$ was 3.97ng/g. The average concentration of thiametoxamin in all postive samples as well as the standard deviaton for it was 0.897±1.14 ng/g. For clothianidin, the values were 0.647±0.79 ng/g. The maximum measured concentration of thiametoxam and clothianidin was 5.03 ng/g and 3.25 ng/g, respectively.

The bee bread samples collected from hives that were located close to oilseed fields in 2013 contained residues of seed treatment neonicotinoids with an amount of 0.7-2.6ng/g. The average $c_{thia+clo}$ and the standard deviation was 1.75±0.70 ng/g.

In 2014, eighty-seven bee bread samples from 71 apiaries were analysed. Similar to the nectar samples, a large proportion of the bee bread samples also contained thiamteoxam and/or chlothianidin. Residues were detected in 36 of the 71 apiaries. In general, the residue levels were slightly lower in bee bread than in nectar. The highest measured sum concentration of $c_{thia+clo}$ was 1.77 ng/g. The maximum measured concentration of thiametoxam in bee bread was 1.38 ng/g. For clothianidin, the maximum measured concentration was 1.31 ng/g. The average concentration of thiametoxam and clothianidin in all postive samples was 0.38±0.32 ng/g and 0.40±0.39 ng/g, respectively.

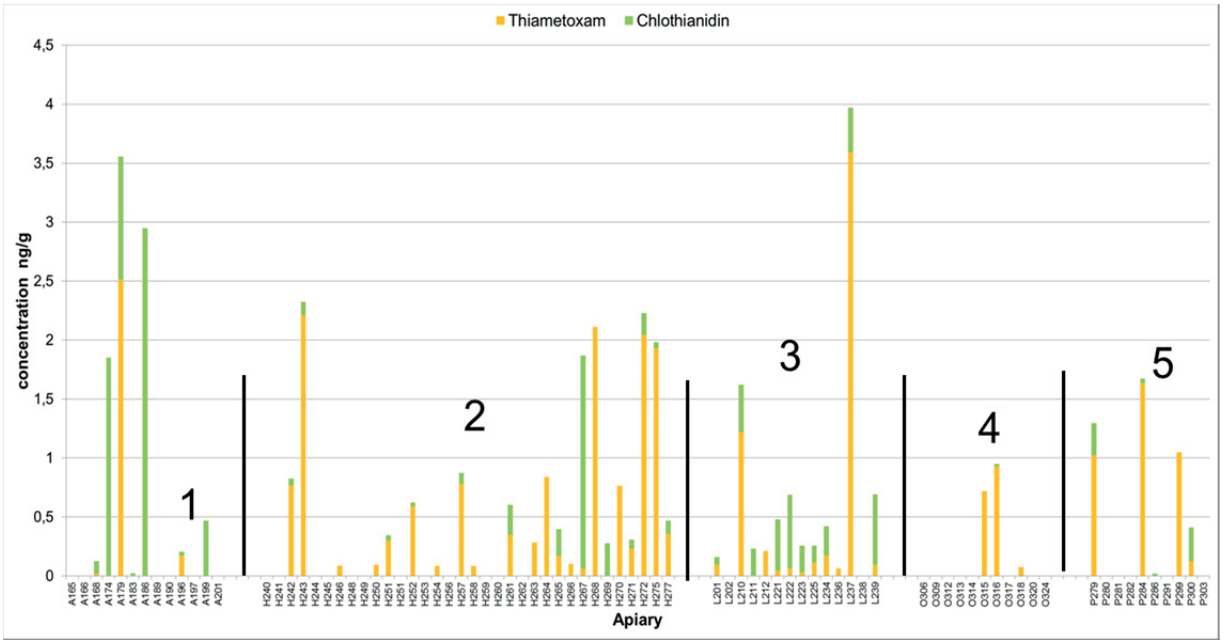

Figure 19. Residues of thiametoxam and clothianidin in nectar collected as a survey from five (1-5) different geographical areas in Finland.

Residues of thiacloprid (Field study, 2013)

In the field study, the sampling point for the nectar and bee bread followed 10 or 16 days of the sprayings. The honey samples, then, were collected four weeks later. The thiacloprid concentrations varied from 26 to 130 ng/g in nectar and from 40 to 114 ng/g in honey (Figure 20). Residues of thiacloprid were either not detected or the level was low (≤0.2 ng/g) in the samples collected from fields to which thiacloprid was not applied.

The bee bread samples collected from fields with neonicotinoid sprayings contained thiacloprid residues with an amount of 30-666 ng/g (9 hive samples).

The pollen samples were collected from two hives on trial site 3 and from one hive on trial site 4. The residue amounts in the different hives of trial site 3 exhibited a correspondence. The samples contained more than 150 ng/g of thiacloprid one week after the spraying was performed (Figure 21). The pollen samples were not collected immediately after spraying. Because of the delay in sampling after spraying, the residue results presented for nectar, perga, or pollen do not provide an accurate portrayal of the maximum concentrations within the hive or in the pollen collected by bees. The maximum concentration levels have probably been remarkaby higher after spraying, since the concentration of tiacloprid in the field decreased rapidly as the time from the spraying point elapsed (Figures 15, 21).

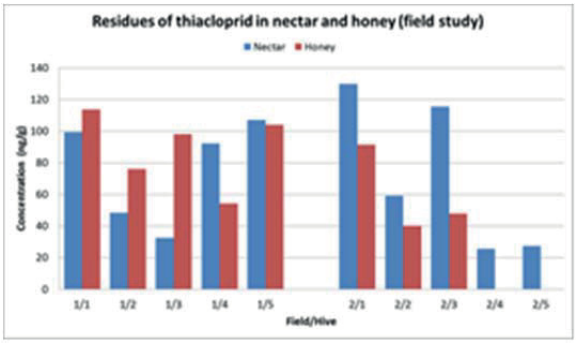

Figure 20. Residues of thiacloprid in nectar and honey in trial fields 3 and 4. Both fields were treated with thiacloprid sprayings. The honey samples were not collected from hives 2/4 and 2/5.

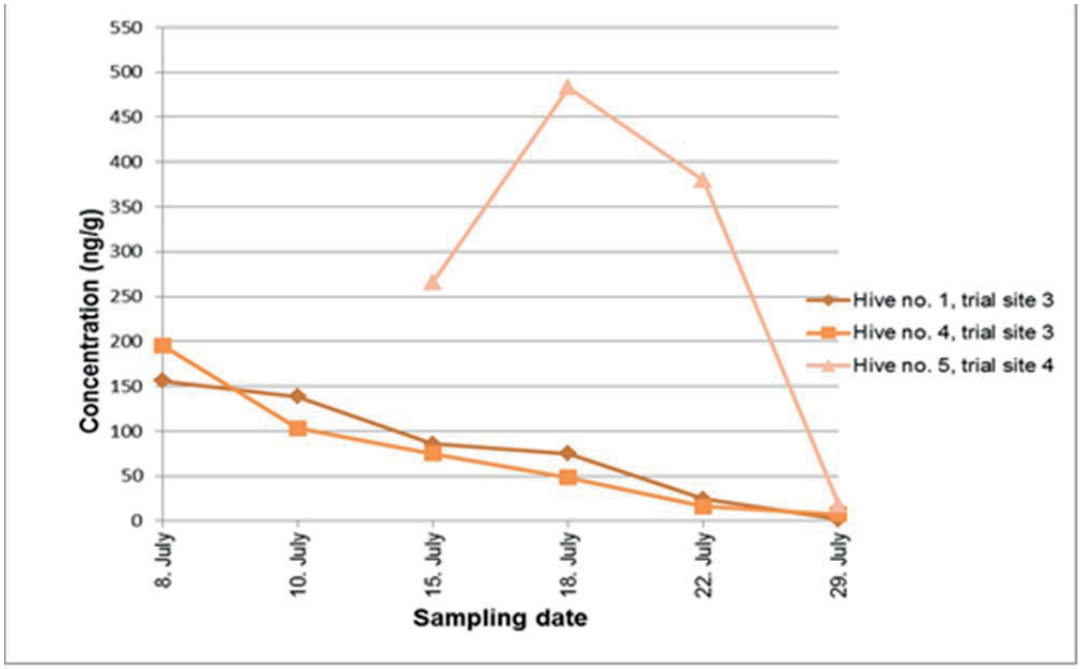

Figure 21. Thiacloprid levels in pollen samples. The spraying points were the following: Test site 3, 1.7.2013 and Test site 4, 8.7.2013.

Residues of other pesticides (other than clotianidin or tiametoxam)

As can be observed from the results above, seed treatment neonicotinoids were detected in both nectar and bee bread. Furthermore, the concentrations were typically higher in nectar. The relatively high hydrophilicity of thiametoxam and clothianidin may explain this. This is not, however, the case with other pesticides, which were detected more often, and in higher concentrations, in bee bread than in nectar. Thus, bee bread is a more representative matrix when monitoring a wider group of pesticides. Table 9 displays the results for other pesticides that were quantified in more than one bee bread sample. In addition to these pesticides, iprodione, lambda-cyhalothrin and deltamethrin were each detected once at the limit of detection.

Table 9. Other pesticides that were quatified in bee bread

	Number of Positive Samples 2013 (n=37)	**Number of Positive Samples 2014 (n=89)**	**Concentration**
Acetamiprid	1	16	two samples: 274 ng/g, 347 ng/g other samples < 4 ng/g
Acetamiprid-N-deshmethyl	0	18	< 0.7 ng/g
Thiacloprid	21	40	0.2- 163 ng/g
Metalaxyl-M	19	16	<1.1 ng/g
Azoxystrobin	2	20	10- 144 ng/g
Tau-fluvalinate	10	11	10-250 ng/g
Fludioxonil	1 (475 ng/g)	4	44 -763 ng/g

Residues in bee samples

Bees, both living and dead, were analysed for residues in the first year of the study. The alive worker bees were collected inside the hives from all trial sites when the fields were flowering. The alive bee samples did not contain any residues ≥log besides thiacloprid. The maximum measured concentration of thiacloprid was low (4.6 ng/g).

The dead bees were collected from the coverages that were spread in front of the hives. The number of dead bees in every trial site was low; less than 100 bees. The highest number of dead bees was collected from trial site 3 (foliar spraying and seed treatment). That sample contained 0.65 ng/g of thiametoxam, 0.71 ng/g of clothianidin, and 25 ng/g of thiacloprid. The thiacloprid concentration in the other dead bee samples was ≤5 ng/g. No seed treatment neonicotinoids or other pesticides were detected in any other samples. Bees typically come from the inside of the hive to the outside to die. Therefore, dead bees in front of hive were not entering the hive while carrying food. This means that the residues in the samples from dead bees represent eaten residues in the body.

4.7. Statistical evaluation of the results of the epidemiological pilot study, Part B

In the analysis of the 18 pilot apiaries, no statistically significant relationship was found between the hive strength and the distance to the nearest oilseed field (P>0.10). Also no significant relationship was found between the hive strength and the total oilseed cultivation area within 1 km (P>0.10), 1.5 km (P>0.10) or 3 km (0.10) radius from the hive.

The amount of thiametoxam and clothianidin in the nectar or bee bread was slightly higher in the hives less than 1 km from the oilseed field than those further from the fields (data not shown), but the difference was not statistically significant.

The amount of thiametoxam and clothianidin in the nectar or bee bread had no effect on the hive strength.

5. Conclusions

This study provides, for the first time, research data from Finnish oilseed cultivation conditions.

The bee colony's developmental rhythm acts as a buffer against the chemical and physical threats in its environment. Due to the honey bee's lifecycle, the bee colony can have nearly 5,000 individuals in egg stage, 10,000 open larvae, and up to 30,000 pupae in sealed cells in July. Furthermore, the bees that are born into the hive do not leave the hive during the first 20 days. They operate within the hive instead. The number of these nurse bees during midsummer ranges from 20,000 to 40,000 depending on the strength of the bee colony.

Towards the end of their lifecycle, the worker bees begin to collect nutrition from the field. This process begins during their last ten days, at the very least. The colony may include 10,000-30,000 of these foraging field bees. The winter bees that are born from the last eggs laid by the queen at the end of summer and in early fall must live for at least eight months in Finland's bee yards. The individual that lives the longest in a bee hive, then, is the queen. It can, in fact, live for as long as four years, but in practice, it is replaced annually or biannually depending on how the hives are managed.

Relatively brief lethal or sub-lethal chemical exposures may only fall upon a certain phase in the lifecycle, such as upon field bees or unsealed larvae through their nutrition. It should be noted, however, that the temporary destruction of a single cast or individual stage of development by chemical exposure will not necessarily destroy the entire colony. As a matter of fact, it will recover from such damage relatively quickly in season. Moreover, if all sealed brood combs are removed artificaly from the colony between June and July, it will recover in approximately five weeks (Büchler 2008). As a result, a lethal chemical dose to an individual bee may be sub-lethal or even completely insignificant to the entire colony.

Exposure through spraying, then, may destroy some of the foraging field bees or larvae inside the hive, but it will not destroy the entire colony. If the winter bees or the queen are exposed to chemicals for a prolonged period of time, however, it may shorten their lifespan or even kill them. This, in turn, would be critical and would endanger the entire colony's existence.

It is for the exact purposes of this study that the research colonies were constructed. To clarify, the test bee colonies were constructed with unused equipment in order to avoid the possible effects of any former cumulative pesticides in the research data. The effects are caused by the fact that the half-life of clothianidin in aerobic conditions in soil ranges from 6 months to 2 years. In contrast, the half-life of thiamethoxam ranges from 25 to 100 days. Nevertheless, no research data exists on the preservation of thiamethoxam or Clothianidin in bee hive material in Finland's conditions.

In addition to the unused equipment, the bees that were collected for the different colonies were homogenised in a large swarm box. The aim of the process was to ensure that the possible *Varroa* mite infection would be equal in all hives. Moreover, the bees fasted and the swarms that were formed from a collective mass of bees were distributed onto unconstructed wax foundations, so that the bees' intestine would be cleansed from any possible *Paenibacillus larvae* spores. In other words, the objective was for the bees to initially be as healthy as possible.

The colonies were established at the beginning of the season when no local Finnish queens were available. Because of this, the artificial swarms were provided with Italian imported queens. As a result, their genetic fitness to the experimental environment was random and may have had an effect on the hives' performance. Hatjina et al (2014) have, in fact, illustrated that bees that are originally from a given area perform better in that area than foreign populations.

Of the 30 queens at the beginning of the test in May 2013, 11 remained after two seasons at the end of August in 2014. They were then replaced with daughter queens. After the second overwintering, the amount decreased further and only 9 queens remained. Despite this, the amount of data is not significant enough to determine the effect of neonicotinoids on queen supersedure. Sandrock et al (2014) discovered a significant association of neonicotinoid exposure and queen supersedure (in the absence of swarming) ($P = 0.01$): while all 10 queens of the control group survived until the end

of the experiment (2 years or swarmed), 6 of the 10 queens from the colonies that were experimentally exposed to thiamethoxam and clothianidin for over 18 months were replaced within a year after the treatment.

At the beginning of the test in 2013, the amount of adult bees was equal in all test bee colonies. In contrast, the amount of brood in the hives was different before the colonies had even been transferred to the test sites. Before the transfer, the colonies had been stored at the same confined forest bee yard. This inconsistency is an indication of the fact that the queens were heterogeneous and that their potential for reproduction was different. Therefore, the amount of brood and the combined amount of adult bees was initially greater in the control and sprayed test field colonies than in the other colonies at the beginning of the experiment. The spare colonies that were left in the confined forest bee yard constituted an additional test site in 2013. As such, the hives' development was followed in the same manner as the hives in the other trial sites.

The amount of adult bees in the site with seed treatment + spraying decreased in comparison to the other sites in the time between the first and second inspection between 25 June and 19 July, 2013 but the decline was not statisticaly significant. The development of the brood area also fell behind the other trial sites. This cannot be explained by the difference in the initial intensity of the brood area. This conclusion is based on the fact that the worker bee develops from an egg into an adult in 21 days, and a normal amount of bees had been born into the test hives before the second census. In this case, the adult bees were lost before the brood area diminished in comparison to the other test colonies.

If one were to assume that the shape of the developmental curve normally resembles a bell, it is possible that the losses have been few thousands bees per hive. The reason for the decrease in the number of adult bees may have been the fact that the site's spraying was purposely conducted on flowering growth on 1 July, 2013.

Finally, the early-summer development of the brood area in the seed treatment + spraying site is also weaker when it is compared to the other test sites' colonies. The difference in the comparison does not, however, apply to the forest bee yard. Then again, the development increases beyond that of the other sites around the third and fourth inspections.

The most notable aspect is that the developmental curve for adult bees in the forest bee yard is very significantly different in comparison to the field ecosystem. This difference can also be observed in the brood area, although it decreases towards the end of summer. In terms of the hives' development, the forest ecosystem appears to be more spring and summer-oriented, whereas the field ecosystem is, in this case, more midsummer-oriented.

In test site 4, which was sprayed, thiacloprid was sprayed on the flowering growth on 8 July, 2013, but no immediate effect to the test hives' adult bees could be observed. Nevertheless, the increase in the number of bees on the site diminished between the second and third censuses. Furthermore, the amount began to decrease in early August. The decrease of the brood area in midsummer results in a decreased number of bees at the end of the season. The developmental curve for adult bees does indeed significantly differ from the other sites' developmental curves in 2013, and the amount of adult bees and brood remains on a significantly lower level over the course of the season. This type of significant difference in the developmental curve may indicate that the bee colonies suffered from the spraying.

The very strong development of the seed treatment + sprayed test bee colonies during the middle and end of summer in 2013 allowed them to recover from their weak development at the end of June and beginning of July. The recovery from the loss of the adult bees occurred within two weeks and the strong development continued throughout August. In fall, on 28 October, 2013, the number of adult bees was significantly greater than in the other test field colonies. After overwinter, from 22 to 23 April, 2013, only the hives on the sprayed test site were almost significantly weaker compared to the other test hives. Aside from that, the hives were equally strong, statistically.

In 2014, the average rhythms of population development differ from each other between test site bee colonies even though there are no differences in the number of adult bees combined with the amount of brood over the course of the season. The development of the test bee colonies in the sprayed test field was significantly stronger until the middle of July. However, the number of adult bees stagnates or diminishes remarkably in all test field bee colonies between the second and third census. This cannot be explained by the diminishing of the brood areas, since only the adult bees disappeared. Even though the diminishing of the adult bee populations corresponds to the time window of the sprayings (14 and 28 July in test fields 3 and 4 respectively), it cannot be the only reason because the loss of adult bees was detected in all test bee yards. After the loss of the adult bees during July and early August, the population of the test bee colonies increased again until the end of August. This, once again, displays well the bee colonies' ability to recover from severe losses. Only the control test field colonies fell behind from the other colonies. It also failed to achieve a good amount of winter bees.

It appears that the spraying of the flowering field with thiacloprid posed an acute threat for adult bees in the test bee colonies. The bee colony can recover considerably quickly from a severe loss of field bees when the sealed brood area is not damaged in a similar manner. In any case, the economical productivity of the bee colony can suffer seriously from the loss off field bees. The damages caused by spraying usually occur in the middle of the growth season. This provides the bee colony with an opportunity to raise an adequate number of winter bees for successful overwintering.

The Over Wintering Index (OWI) indirectly describes the winter bees' lifespan. To clarify, it is the proportion of the number of alive winter bees left in spring in comparison to the number of winter bees at the beginning of overwintering. It is a complicated figure because of the bee colonies' considerable variation in their early spring development and the differences in spring weather. Some of the bee colonies begin to rear brood as early as in February and as a result, several young adult bees will already have been born in April. Furthermore, a bee colony can lose more individual bees during a harsh winter than during a mild one. The notable differences in the OWI numbers during the two years of monitoring can be attributed to these reasons. In this study, no statistical differences were observed in the winter bees' lifespan based on the OWI. Moreover, it is a very approximate method of measurement and as such, it cannot separate minor differences in the individual lifespans of winter bees.

Even though the test bee colonies did not appear to have been visibly or statistically damaged, the residual analysis demonstrated sub-lethal residues in bee products. The detrimental effects of long-lasting exposure to low doses of pesticides should be apparent in the shortening of the lifespan of long-living individuals, such as in winter bees and in the honey bee queen. Then again, the winter bees' metabolic rate is low and the winter feed is usually cane sugar, which the bee keeper supplies to the bee colonies in fall. Honey is preferable winter feed in organic bee keeping only.

The development of the bee colony depends on the food resources of the surrounding environment. Because of this, poor diversity in the environment or a lack of nectar and pollen plants causes starvation. A positive change in foraging abilities advances the colony's development. In the forest bee yard, for instance, the foraging abilities are good in spring but diminish in mid and late summer. This results in different population dynamics compared to field ecosystems where midsummer is the richest season for nectar.

The differences in colony development in this study may also originate from several sources other than pesticides. As an illustration, the queens' genetic differences cause different results in colony development. Furthermore, food sources also differed between trial sites, and there may have been unknown sources of cumulative pesticide in the foraging area of the test bee colonies, which may have had an impact on colony development. Finally, foreign bee yards may have been competitive foragers or served as sources of infection for the test bee colonies.

There are several methods to support or improve the diversity of field ecosystems. Pollinators require diverse and safe food sources in order to develop proper colonies and to recover from chem-

ical and physical injuries. To compensate for the risks of using pesticides, recovering zones should be established for pollinators in intensive agroecosystems to also ensure the essential ecosystem services for plant production.

The residues of neonicotinoids were analysed from samples collected from the trial sites (field study) and from samples collected as a survey from around Finland (Epidemiological pilot study). Unfortunately, the residue studies in the field study failed in many respects. Therefore, the residue results are not comparable to corresponding treatments of the test fields, but they represent the general situation in the Jokioinen area.

In 2013, residues of seed treatment neonicotinoids thiametoxam and clothianidin were discovered in the nectar and bee bread samples collected from all test fields, as well as from two fields which were not treated with seed treatment products. In those samples, the amount of residues was even on a higher level than in the samples collected from the treated fields. Clothianidin was expected to appear in the samples, as clotianidin is the primary metabolite of thiametoxam in plants. Nevertheless, the relatively high amount of clothianidin in the samples from trial site 2 indicates that the residues originated from the field treated with clotianidin rather than from the test field that was treated with thiametoxam. The explanation for the illogical residue result is that the bees have probably flown further from the test fields for feed. The residues have undouptedly originated from other oilseed fields because the use of thiametoxam and clothianidin is limited. Furhermore, oilseed crops are the only crops that attract bees and for which thiametoxam and clothianidin are approved. In addition, the results from the analysis concerning the pollen's origin support the conclusion (Table 4). The nectar and bee bread samples that reflect what bees have carried into the hive during previous days were collected outside of the full flowering period. A subsequent analysis of the other oilseed cultivation areas near the trial sites revealed that there were other oilseed cultivation areas within a distance of less than 3 km (Appendix 4). In those fields, either thiametoxam or clothianidin products were used for seed treatment. As an example, there were two thiametoxam treated fields within a distance of 1.359 km and 1.928 km from the control field (Appendix 4). This explains the relatively high concentrations of thiametoxam in the hive samples from trial site 1. The maximum concentration of thiametoxam in nectar was, in fact, 4.2 ng/g.

In contrast to 2013, the nectar and bee bread samples collected from fields that were not treated with seed treatment products (trial site 1 and 4) did not contain residues of thiametoxam or clothianidin in 2014. An analysis of the pollen's origin, however, demonstrated that the pollen did not originate from oilseed. As a result of sampling outside of the trial field's full flowering period, the nectar and bee bread reflected other vegetation. In 2014, trial sites 1 and 4 were redrilled, which delayed the flowering until autumn when there were no other flowering oilseed fields nearby. This explains the other food source and the fact that there were no residues of seed treatment neonicotinoids in the hive samples. Unlike the residues in all other hive samples in 2013-2014, the residues in the nectar and bee bread samples collected from trial sites 2 and 3 (seed treatment with thiametoxam) in 2014 most likely represent the residues from the test fields. This is due to the fact that the samples were collected during the test field's full flowering period. Moreover, no other oilseed cultivation occurred within a distance of less than 1 km. The average concentration of both clothianidin and thiametoxam was low. The amount of thiametoxam in nectar was 0.36±0.30 ng/g, whereas the amount of clothianidin was 0.06±0.02 ng/g. This does not, however, represent the highest levels of concentration, as the food sources contained a relatively high amount of other vegetation as well. The average content of Brassica pollen grains in nectar samples was 37.7±32.6% (Site 2) and 65.8±18.5% (Site 3).

The concentrations of seed treatment neonicotinoids in nectar and pollen are approximately constant throughout the flowering period. Therefore, worker bees are exposed to seed treatment neonicotinoids continuously if the main source of food is a treated plant. In contrast, exposure to the foliar spraying neonicotinoid tiacloprid is substantial immediately, as well as a few days after the spraying. This contributed to the fact that residues of thiacloprid were only detected in samples col-

lected from the trial site where foliar spraying with tiacloprid was applied. Furthermore, no high contamination due to residues derived from other oilseed areas was observed in the samples from fields with no spraying treatment. The concentrations of tiacloprid in the samples varied considerably depending on the hive, field, point of sampling, and growing season. The levels of tiacloprid measured in the samples were remarkably higher in the samples of 2013 than in those of 2014. There is no clear explanation for this, but in the samples of 2013, the pollen primarily originated from Brassica, whereas in 2014, the relative amount of pollen from other plants was higher. The highest tiacloprid concentrations measured in the field study were 130 ng/g in nectar, 114 ng/g in honey, 666 ng/g in bee bread and 482 ng/g in pollen.

The residue studies, as a part of the epidemiological pilot study (survey study), evidently provide a good estimation of the residue levels of seed treatment neonicotinoids in bee hives in Finnish oilseed cultivation. In 2013, samples from 37 hives were collected from one geographical area in South-West Finland. The residue data definitely illustrates that the proximity of oilseed fields to the apiary affects the amount and frequency of thiamtoxam and clotianidin residues in the samples. In 2014, samples were collected from 202 hives (82 apiaries) from five different geographical areas, including areas where oilseed was cultivated to a lesser degree. The sampling was not optimised, for instance, for the time when the oilseed crop was flowering. Despite this, residues of seed treatment neonicotinoids were detected in samples from all geographical areas and in both bee bread and nectar. The concentrations were typically higher in nectar. The prevalence of seed treatment neonicotinoid residues in the hives was significant. Thiametoxam and/or clothianidin were detected in 49 nectar samples of the 82 sampled apiaries. The highest measured sum concentration of thiametoxam and clotianidin $c_{thia+clo}$ was 3.97 ng/g. The average concentration of thiametoxamin in all positive nectar samples, as well as the standard deviation for it, was 0.897±1.14 ng/g. For clothianidin, the values were 0.647±0.79 ng/g. The maximum measured concentrations of thiametoxam and clothianidin were 5.03 ng/g and 3.25 ng/g, respectively.

The residue studies demonstrated that nectar is a representative matrix when monitoring thiametoxam and clothianidin, most likely due to their hydrophilic structure. In contrast, other pesticides were more often, and in higher concentrations, detected in bee bread rather than in nectar. Thus, bee bread is a more suitable matrix for screening pesticides.

The limit of detection in the analytical method was very low. For neonicotinoids in nectar, for instance, the limit was 0.05 ng/g. Residues were detected at a relevant level, especially in the case of thiametoxam and clotianidin, which possess substantially high toxicity (Table 10). An approximate estimate of the exposure to neonicotinoids for the worker bee can be calculated based on the residue results. The worker bee's rate of food consumption and exposure to residues is higher than that of the queen bee and brood. Additionally, the exposure is simply an estimable, as the worker bee's only food source is nectar. Using the maximum consumption of sugar and pollen used in risk assessment for the worker bee (128 mg sugar/bee/day), the 60% sugar content of nectar, and the residue levels measured in the nectar, the exposure to thiametoxam +clothianidin can be estimated (Table 10). In table 10, the exposure is calculated for maximum measured concentrations (the worst-case scenario) and the average concentrations of positive samples. Moreover, exposures using the sum concentration of thiametoxam and clotianidin are also represented. This is a relevant procedure, because thiametoxam and clothianidin possess a similar mechanism of action and toxicity and as such, one cannot be evaluated without accounting for the other. If the exposure is compared to the toxicological end point values (Table 11), the concentrations are close to the sub lethal risk limits with a minimal safety factor. The chronic and acute sub lethal risks cannot be excluded based on these estimations. The results are in line with the EFSA conclusion regarding thiametoxam and chlothianidin (EFSA 2013 a, b).

As a conclusion of the residue studies of seed treatment neonicotinoids, thiametoxam and clothianidin migrate into bee hives with pollen and nectar and are very common residues in honey bee hives around Finland. Because the residue levels are close to sub lethal risk limits, mixture interac-

tions with other stress factors, such as other pesticides, other toxic compounds, disease, or environmental conditions, may be critical for colony surveillance.

The toxicity of thiacloprid, the neonicotinoid in spraying products, is thousands of times lower than the toxicity of seed treatment neonicotinoids. The LD50 for thiacloprid is 14.6 ug/bee. The maximum amount of thiacloprid measured in the samples of this study is clearly hundreds of times below the acute risk limits. Nevertheless, the mixture toxicity of several active compounds applied at the same time should be taken into account. In this case, for instance, the simultaneous exposure to thiacloprid, thiametoxam and clothianidin should be considered.

Table 10. Exposures to thiametoxam and clotianidin for worker bees calculated by using different residue data; maximum measured concentrations and average concentrations.

	Residues in nectar ng/g	**Exposure ng/bee/day**
Max sum concentration of Thiametoxam and Clothianidin	5,7 ng/g	1,22 ng/bee
Max Thiametoxam concentration	5.03 ng/g	1,07 ng/bee
Max Clothianidin concentration	3.25 ng/g	0.70 ng/bee
Sum concentration (Clo+Thia) in hives near oilseed cultivation 2014 2013 (n=18)	2.75 ng/g ±1.47 ng/g	0.27–0.90 ng/bee
Average concentration of Thiametoxam in all positive samples (n=73)	0.897ng/g ±1,14 ng/g	0-0.40 ng/bee, mean 0.20 ng/g bee
Average concentration of Clothianidin in all positive samples 2014 (n=67)	0.647 ng/g ±0,79 ng/g	0-0.30 ng/bee, mean 0.14 ng/g bee

Table 11. Toxicological end point values for chlothianidin and thiametoxam. (LD50=median lethal dose, NOEC=No observed level of effect). (Efsa Journal 2013c)

Substance	**Toxicolocical end point**	
thiametoxam	acute oral LD50	5 ng/ bee
clothianidin	acute oral LD50	3.79 ng/ bee
thiametoxam	sublethal dose	1.34 ng /bee
clothianidin	sublethal dose	0.5 ng/ bee
thiametoxam	chronic 10-dayLC50	> 0.2 ng/ bee/day
clothianidin	chronic 10-day NOECbee	8.13 ng/g food

After counting the number of pollinators in the flowering turnip rape crop, it can be concluded that the foliar spraying with the neonicotinoid thiacloprid during the flowering resulted in a significant decrease in the number of honey bees for two days. However, the number of honey bees clearly increased again two to three days after the foliar treatment. Moreover, in trial sites 2 (2013) and 4 (2014), where the maintaining of a proper crop stand failed, the number of honey bees was lower compared to the trial fields with normal crop growth in 2013 and 2014. The conclusions are not unambiguous, since the number of honey bees may vary in relation to the density of the crop growth. In other words, the better the crop growth is during flowering, the more it will attract the honey bees and vice versa. That is to say, a poor crop growth and a lower number of flowering plants resulted in a lower number of honey bees. The fairly rainy period during the flowering of turnip rape also attracted the honey bees less. An increase in the number of flower flies in particular may be due to late blooming. Then again, it may have been caused by the environment or the habitat around the trial fields, rather than the treatments conducted in them.

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7. Appendices

Appendix 1. The table for the activities in the field study of NEOMEHI Project carried out in 2013-2014.

2013	**Trial site 1**	**Trial site 2**	**Trial site 3**	**Trial site 4**
Farm, farmer name, Postal code and gps-location of NEOMEHI Trial site	1.Trial site: Laurila, S. Raiskio, FI- 31600 Jokioinen Location: Somero N 6738372 E 303039	2.Trial Site: T. Jaska, FI-30100 Forssa, N 6747940 E 318711	3. Trial Site: Mäkelä, H. Jalli, FI-31500 Koski, N 6729954 E 289281	4. Trial Site: MTT Agrifood Research Finland, FI-31600 Jokioinen, N 6745860 E 309922
Planting method, previous crop, machinery	2013: Glyphosate before drill (2012 timothy seed grass), direct drilling (VM)	2013: Glyphosate before drill (2012 barley), direct drilling (Tume)	2013: Conventional tillage, (spring wheat 2012), conventional drilling (Juko)	2013: Glyphosate before drill (2012 barley), direct drilling (VM)
Seed treatment/variety/Lot code / Germination rate	Uncoated / Apollo / BOR 357-01059B / 98%	Cruiser OSR 15 ml/kg /Apollo / BOR 357-01059B / 96%	Cruiser OSR 15 ml/kg/ Apollo / BOR 357-01059B / 96%	Uncoated / Apollo / BOR 357-01059B / 98%
Sowing date, Seeding rate kg/ha (real seeding-rate may change from target rate according to drilling method, soil moisture etc.)	29.05.2013, 13 kg/ha (10 kg/ha)	17.05.2013, 10 kg/ha (8-10 kg/ha)	18.05.2013, 6 kg/ha (8-10 kg/ha)	29.05.2013, 10kg/ha (10 kg/ha)
Foliar spraying against flea beetles, (*Phyllotreta* sp.).	-	Pyrethroid (Sumi alpha 5 FW) 06.06.2013,	Pyrethroid (Decis Mega EW 50) 07.06.2013, 10.06.2013	-
Foliar spraying against pollen beetles (*Meligethes aneus*)	Pyrethroid Sumi alpha 5 FW 28.06.2013	Pyrethroid Sumi alpha 5 FW 19.06.2013	Pyrethroid Sumi alpha 5 FW 20.06.13 Biscaya OD 240 0.35 l/ha 01.07.2013	Pyrethroid (Sumi alpha 5 FW) 28.06.2013 Biscaya OD 240 0.35 l/ha 08.07.2013
Principal growth stage at foliar spraying	-	-	Flowering stage BBCH 63-64 (at minimum late bud stage)	Flowering stage BBCH 63-64 (at minimum late bud stage)
FungicideFungicide	-	-	-	-
Harvesting date	09.09.2013	23.09.2013	17.09.2013	09.09.2013

2014	**Trial site 1**	**Trial site 2**	**Trial site 3**	**Trial site 4**
Farm, farmer name, Postal code and gps-location of NEOMEHI Trial site	1.Trial site: Laurila, FI- 31600 Jokioinen Location: Somero N 6738372 E 303039	2.Trial Site: MTT Agrifood Research Finland, FI-31600 Jokioinen, N 6747914 E 310145	3. Trial Site: Laurila, FI- 31600 Jokioinen N 6740396 E 304715	4. Trial Site: MTT Agrifood Research Finland, FI-31600 Jokioinen, N 6745806 E 309895
Planting method, machinery	Glyphosate before drill	Conventional drill	Conventional drill	Glyphosate before drill
Seed treatment/variety/Lot code / Germination rate	Uncoated / Apollo / BOR 357-01059B / 98%	Cruiser OSR 15 ml/kg /Apollo / BOR 357-01059B / 96%	Cruiser OSR 15 ml/kg/ Apollo / BOR 357-01059B / 96%	Uncoated / Apollo / BOR 357-01059B / 98%
Sowing date, Seeding rate kg/ha	18.5.2014, redrill 28.6.2014 8 kg/ha	20.05.2014, 10 kg/ha	18.05.2014, 10 kg/ha	24.05.14, 10 kg/ha, redrill 16.6.2014, 8.4 kg/ha
Foliar spraying against flea beetles, (*Phyllotreta* sp.).	Pyrethroid (Sumi alpha 5 FW) 30.5.2014	Pyrethroid (Sumi alpha 5 FW) 10.6.2014	Pyrethroid (Sumi alpha 5 FW) 11.6.2014	Pyrethroid (Sumi alpha 5 FW) 4.6.2014, 9.6.2014
Foliar spraying against pollen beetles (*Meligethes aneus*)	-	-	Neonicotinoid Biscaya OD 240 0.25 l/ha 14.7.2014	Neonicotinoid Biscaya OD 240 0.35 l/ha 28.7.2014
Principal growth stage at foliar spraying	-	-	Flowering stage BBCH 63-64 (at minimum late bud stage)	Flowering stage BBCH 63-64 (at minimum late bud stage)
Fungicide	-	-	-	-
Harvesting date	2.9.2014	8.9.2014	12.9.2014	29.9.2014

Appendix 2. Seed Treatment Analysis Report of treated seed used in 2013 and 2014. Syngenta Seedcare Institute 14.4.2014

Appendix
478-1401-E-FI-OTH-OIL-CRO - 4/14/2014 10:27:39 AM 1 of 1

syngenta

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mob : +358 500 281717
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SeedcareInstitute™

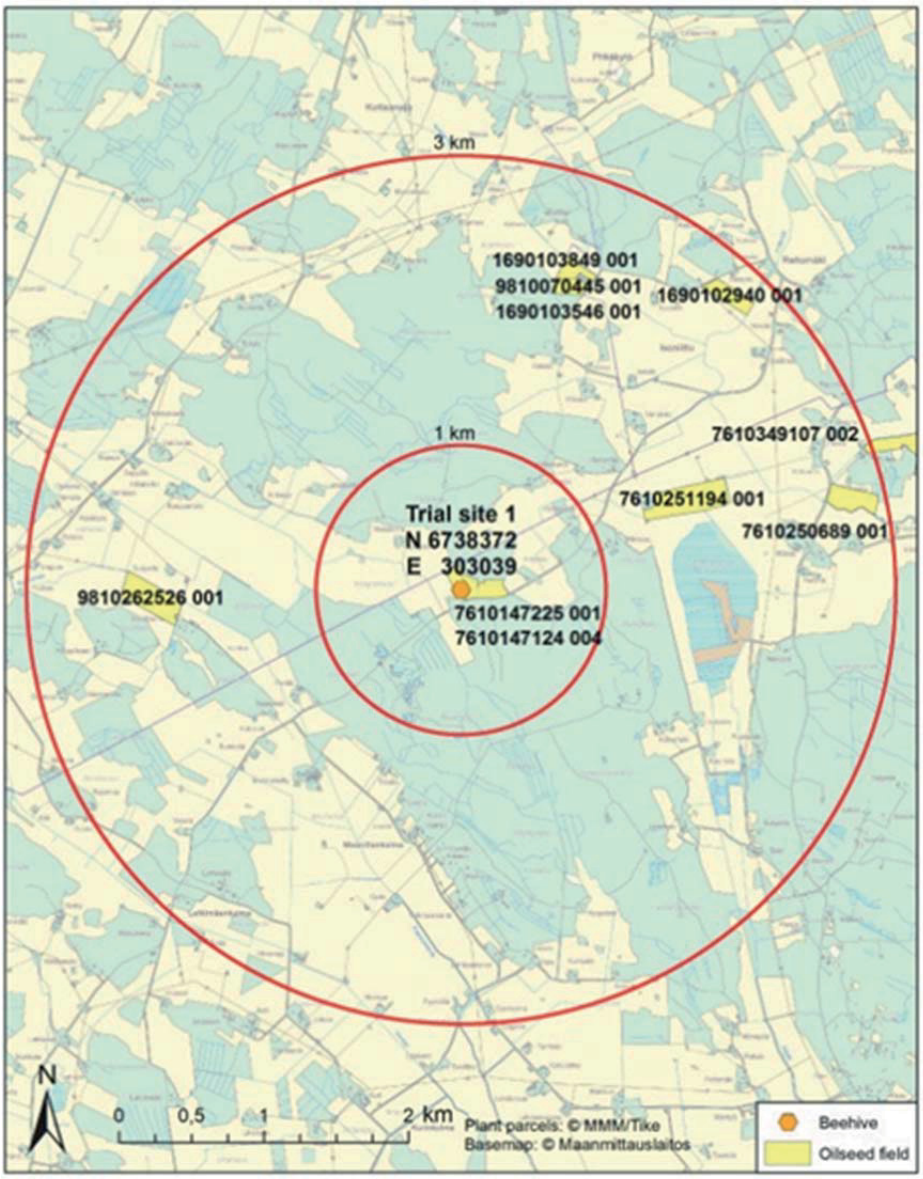
Seed Treatment Analysis Report 14.04.2014

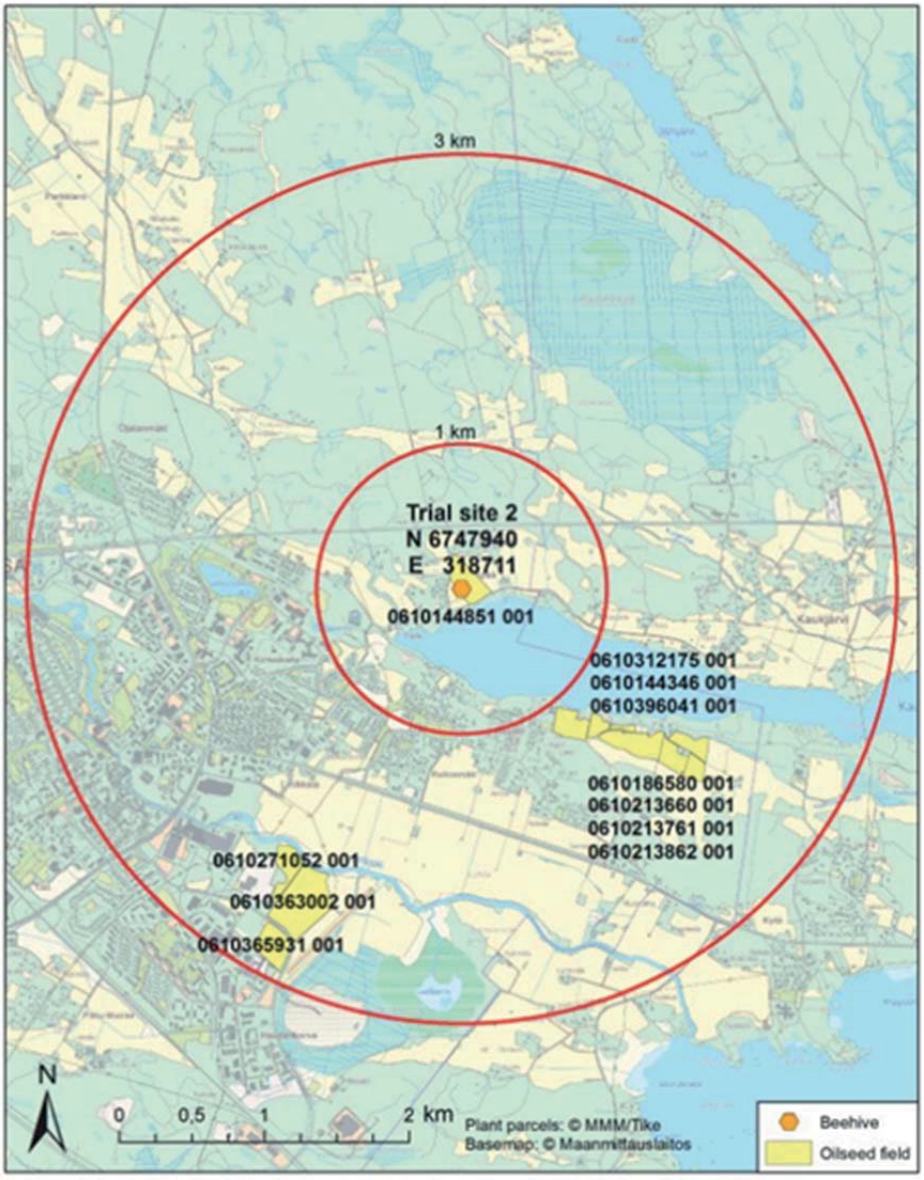
Site	**BOREAL KASVINJALOSTUS OY /**	Customer	**Others**
Seedcare Case	**478-1401-E-FI-OTH-OIL-CRO**	Crop	**Oil seed rape**
Main Product	**Cruiser OSR**	Date of Delivery	
Define analysis and method	**DUST / Heubach 2 min**	**SEED LOADING / HPLC**	**Thiamethoxam**
Remarks	**14.133**		

Sample		**357-01-059B**
ST Batch Id		357-01-059B
Variety		APOLLO
Weight of Samples		279.00
Reception Date		08.04.2014
TGW (g)		2.4
Date of Analysis		11.04.2014
General Remarks		
Dust		
Limit		0.5000 g/700000 seeds
Dust Result		0.0376 g/700000 seeds
Comment		☺
Dust Remarks		
Seed Loading (SLA)		357-01-059B
AI Analyzed	Cruiser OSR	Thiamethoxam
Target Rate	Cruiser OSR	420 g a.i./100 kg
SLA Rate	Cruiser OSR	386 g a.i./100 kg
% of Target	Cruiser OSR	92 %
Comment	Cruiser OSR	☺
SLA Remarks	Cruiser OSR	

Appendix 3. Oilseed fields around 1 and 3 kilometres from Neomehi Trial sites 1-4 in 2013 **(3a)** and 2014 **(3b)**. Oilseed fields are coloured with bright yellow in the maps.

3a)

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1 km
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0610312175 001
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0610213660 001
0610213761 001
0610213862 001
0610271052 001
0610363002 001
0610365931 001
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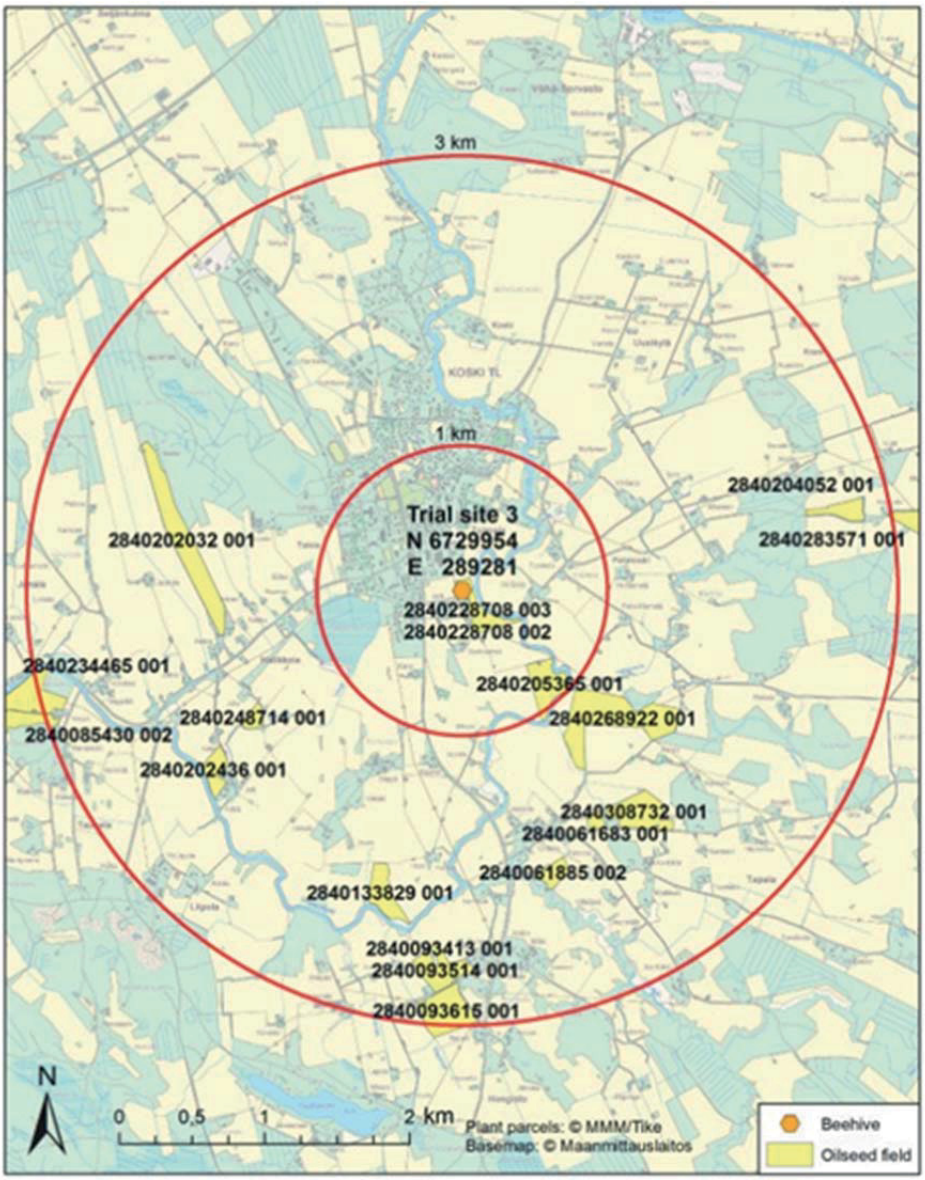
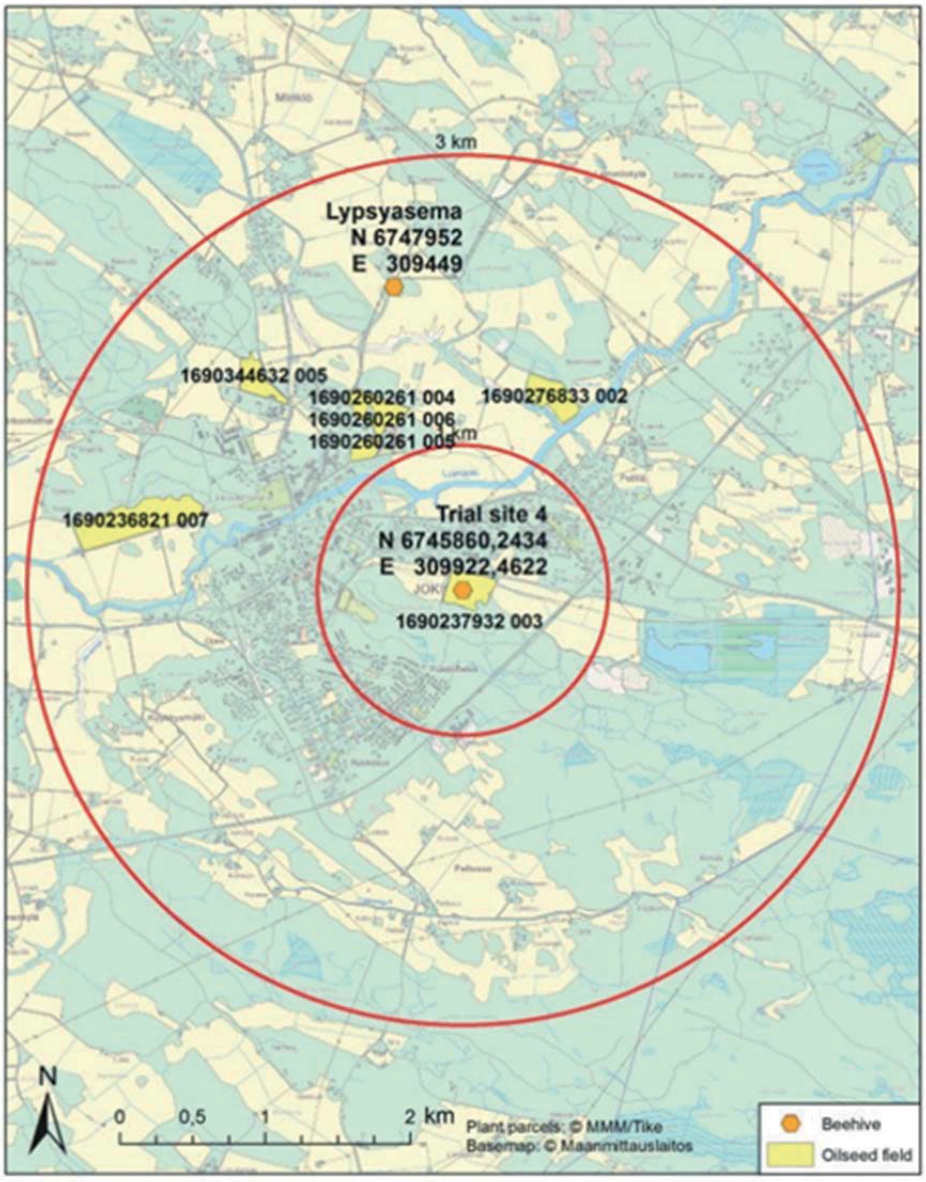
1
2 km
Plant parcels: © MMM/Tike
Basemap: © Maanmittauslaitos
Beehive
Oilseed field


3 km
1 km
Trial site 3
N 6729954
E 289281
2840202032 001
2840204052 001
2840283571 001
2840228708 003
2840228708 002
2840234465 001
2840205365 001
2840248714 001
2840268922 001
2840085430 002
2840202436 001
2840308732 001
2840061683 001
2840061885 002
2840133829 001
2840093413 001
2840093514 001
2840093615 001
N
0
0,5
1
2 km
Plant parcels: © MMM/Tike
Basemap: © Maanmittauslaitos
Beehive
Oilseed field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Lypsyasema
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E 309449
1690344632 005
1690260261 004
1690260261 006
1690260261 005
1690276833 002
km
1690236821 007
Trial site 4
N 6745860,2434
E 309922,4622
1690237932 003
N
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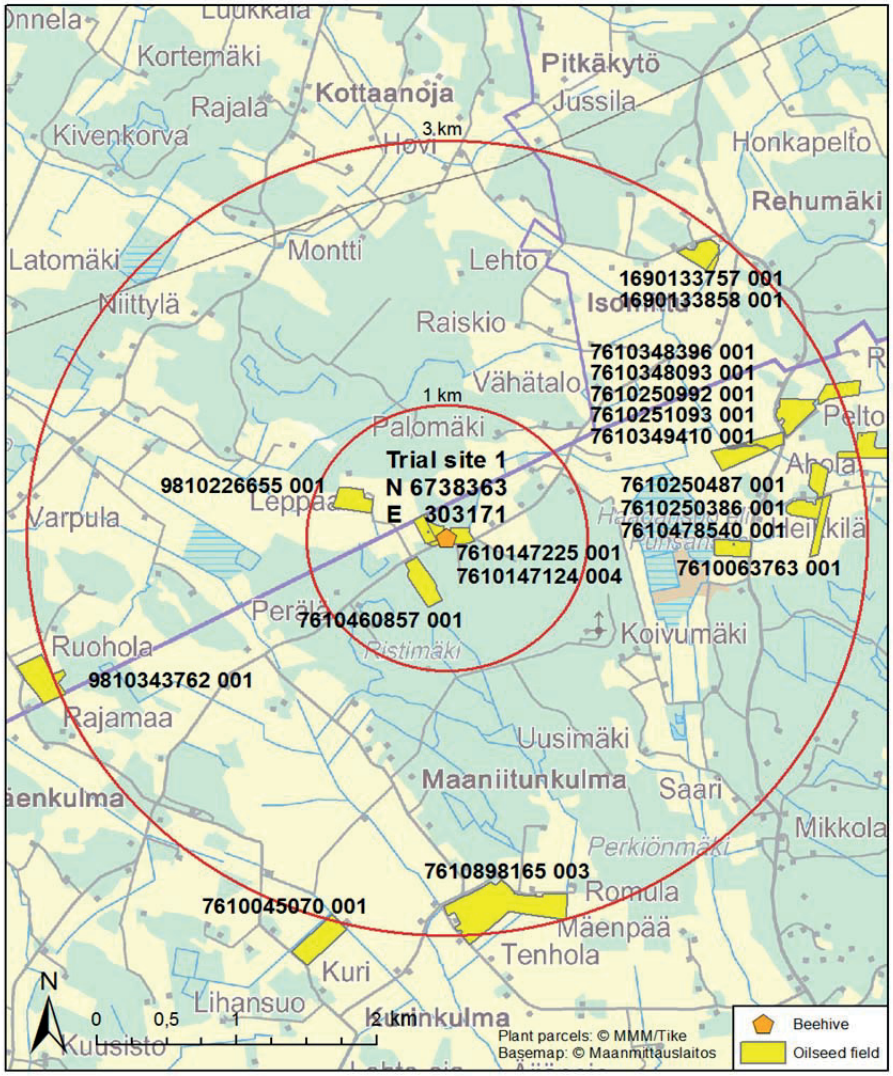
1
2 km
Plant parcels: © MMM/Tike
Basemap: © Maanmittauslaitos
Beehive
Oilseed field

3b)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Kottaanoja
Pitkäkytö
Jussila
Rajala
Kivenkorva
3 km
Honkapelto
Rehumäki
Latomäki
Montti
Lehto
1690133757 001
1690133858 001
Niittylä
Raiskio
7610348396 001
7610348093 001
7610250992 001
7610251093 001
7610349410 001
Vähätalo
1 km
Palomäki
Pelto
Trial site 1
N 6738363
E 303171
9810226655 001
7610250487 001
7610250386 001
7610478540 001
Varpula
7610147225 001
7610147124 004
7610063763 001
7610460857 001
Koivumäki
Ruohola
9810343762 001
Rajamaa
Uusimäki
Maaniitunkulma
Saari
Mikkola
Perkiönmäki
7610898165 003
Romula
7610045070 001
Mäenpää
Tenhola
Kuri
Lihansuo
N
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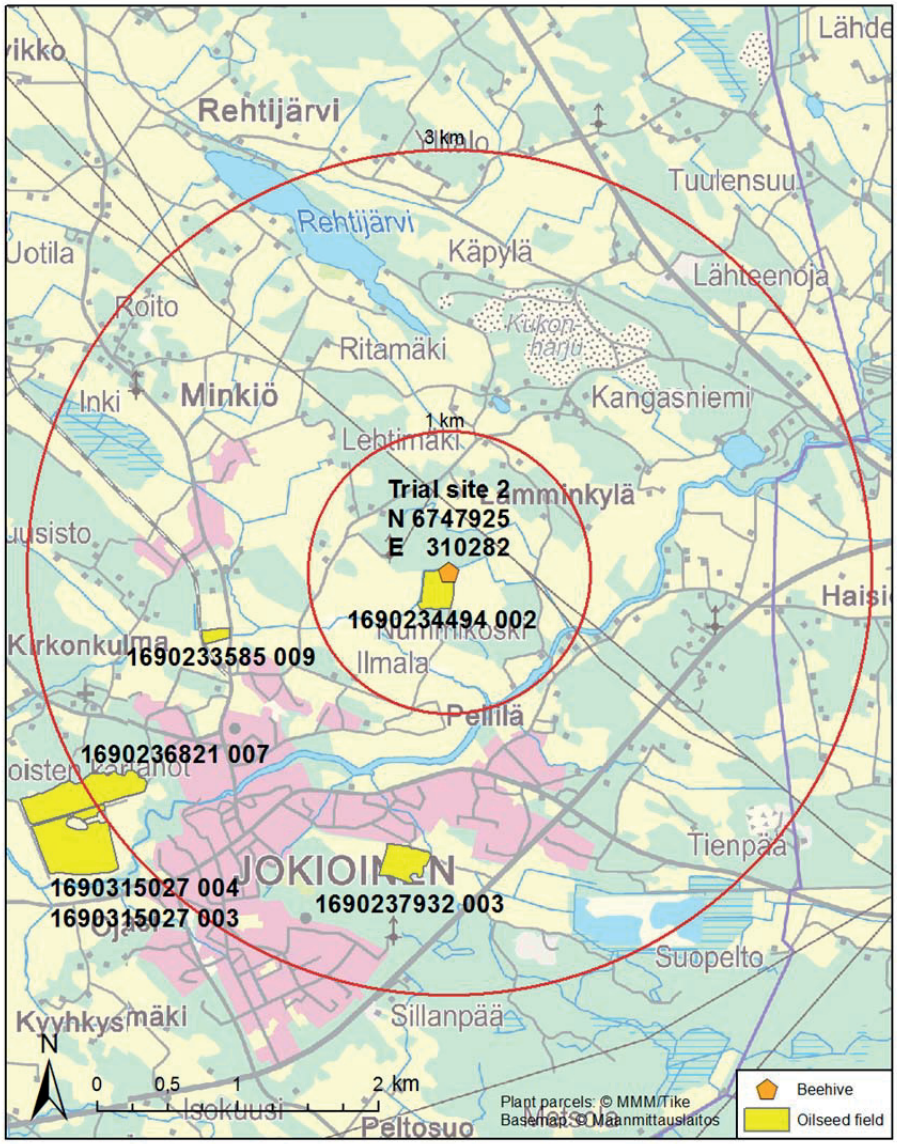
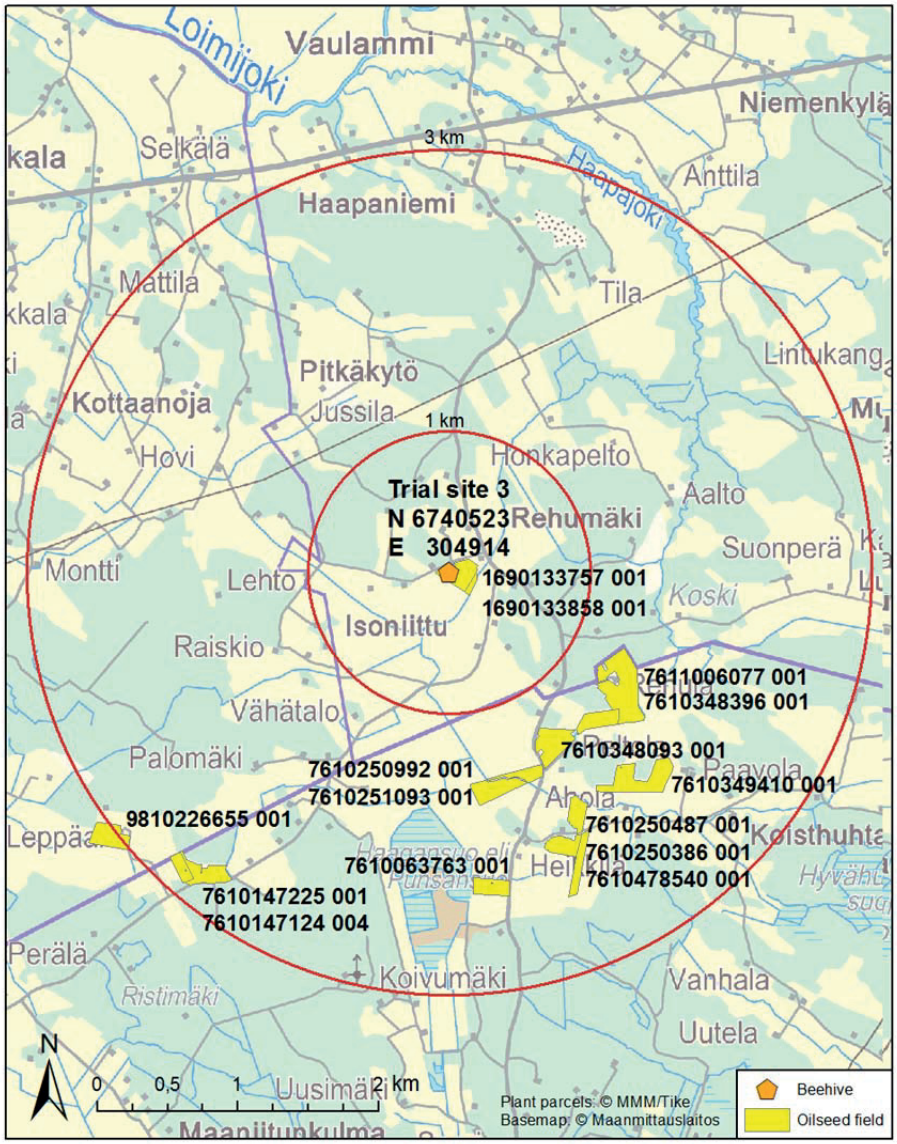
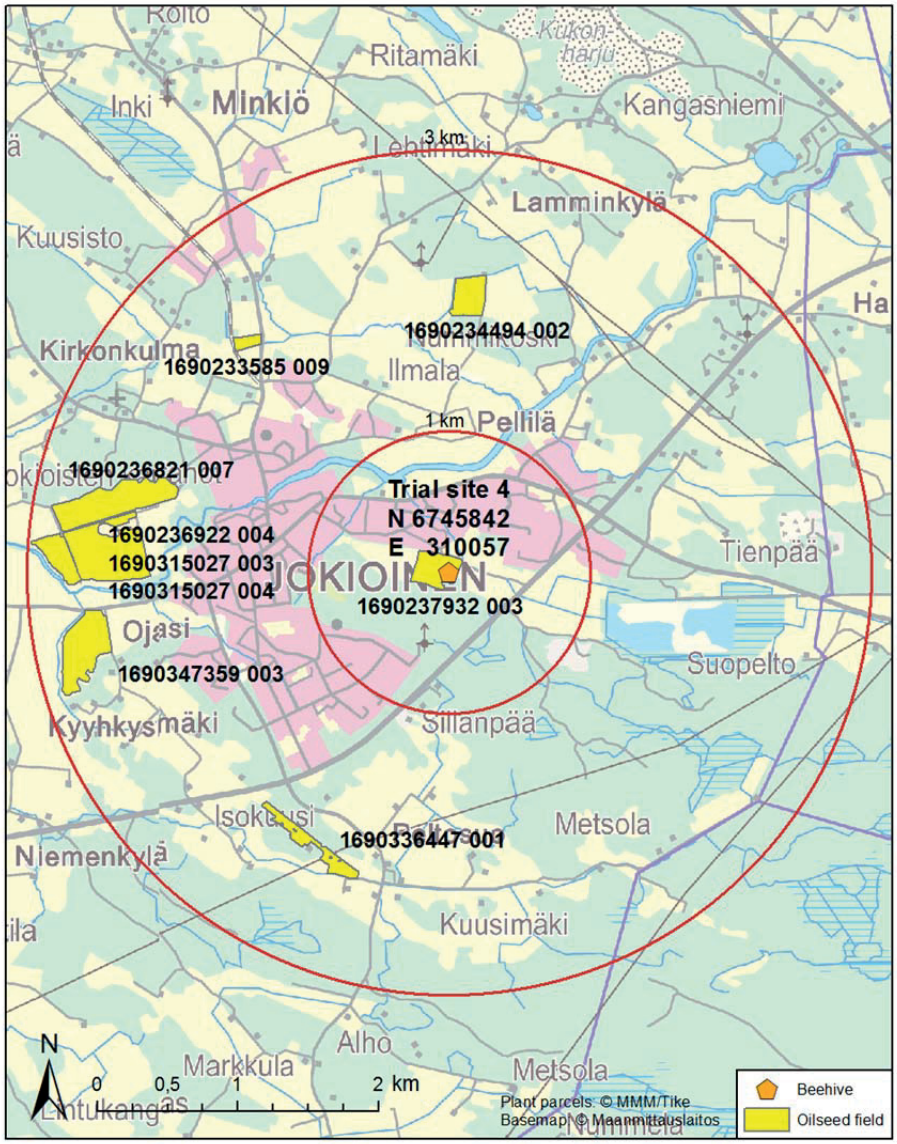
0,5
1
2 km
Plant parcels: © MMM/Tike
Basemap: © Maanmittauslaitos
Beehive
Oilseed field


Rehtijärvi
3 km
Rehtijärvi
Käpylä
Tuulensuu
Lähteenoja
Roito
Ritamäki
Minkiö
Inki
Kangasniemi
1 km
Lehtimäki
Trial site 2
N 6747925
E 310282
1690234494 002
1690233585 009
Ilmala
Pellilä
1690236821 007
JOKIOINEN
1690315027 004
1690315027 003
1690237932 003
Tienpää
Suopelto
Sillanpää
Kyyhkysmäki
Isokuusi
Peltosuo
N
0
0,5
1
2 km
Plant parcels: © MMM/Tike
Beehive
Oilseed field


Loimijoki
Vaulammi
Niemenkylä
Selkälä
3 km
Haapajoki
Anttila
Haapaniemi
Mattila
Tila
Pitkäkytö
Kottaanoja
Jussila
1 km
Hovi
Honkapelto
Trial site 3
N 6740523
E 304914
Rehumäki
Aalto
Suonperä
Montti
Lehto
1690133757 001
1690133858 001
Koski
Isoniittu
Raiskio
7611006077 001
7610348396 001
Vähätalo
Palomäki
7610348093 001
7610250992 001
7610251093 001
7610349410 001
Ahola
9810226655 001
7610250487 001
7610250386 001
7610478540 001
7610063763 001
7610147225 001
7610147124 004
Perälä
Ristimäki
Koivumäki
Vanhala
Uutela
N
0
0,5
1
2 km
Uusimäki
Maanjitunkulma
Plant parcels: © MMM/Tike
Basemap: © Maanmittauslaitos
Beehive
Oilseed field


Ritamäki
Minkiö
Inki
Kangasniemi
3 km
Lamminkylä
Kuusisto
Kirkonkulma
1690233585 009
1690234494 002
Ilmala
1 km
Pellilä
1690236821 007
Trial site 4
N 6745842
E 310057
1690236922 004
1690315027 003
1690315027 004
1690237932 003
Tienpää
Ojasi
1690347359 003
Suopelto
Kyyhkysmäki
Sillanpää
Metsola
1690336447 001
Niemenkylä
Kuusimäki
Alho
Markkula
Metsola
N
0
0,5
1
2 km
Plant parcels © MMM/Tike
Basemap © Maanmittauslaitos
Beehive
Oilseed field

Appendix 4. Year 2013. Plant protection products used in the neighboring oilseed fields of trial site 1 and MTT Lypsyasema. Bee hives were temporarily placed in the MTT lypsyasema before being moved to trial site 1.

Field	Location/village of the neighboring OSR- field near the test bee hives	Distance between OSR-field and test bee hive m, area of OSR field ha	Plant protection products for foliar applications, active ingredients	Foliar appli-cation dd.mm.yy	Seed coating of osr seed, product, drilling in May 2013	Beehives in the Trial site during dd.mm-dd.mm.yy
Trial site 1	Lehtimäenkulma	1359m	Mospilan (acetamiprid)	11.06.13	Cruiser OSR (thiametoxam, metalaxyl, fludioxonil)	28.06-31.07.13
			Avaunt (indoxacarb) +Cyberkill (cybermethrin)	22.06.13		
	Vähäsuo	1928m, 7.44 ha	Cyberkill	30.05.13	Cruiser OSR	
			Focus Ultra + Decis (deltamethrin)			
Väliparkki MTT lypsy-asema	OSR trial fields	around 1000m, total area 2 ha	Biscaya OD 240 (thiacloprid)	24.06.13, 26.06.13 01.06.13-20.06.13	Cruiser OSR, Elado FS 480 (clothianidine, betacyfluthrin)	24.06-28.06.13
			Karate 2.5 WG (lambda-cyhalothrin)	03.06.13, 27.05.13, 30.05.13, 03.06.13, 25.07.13	Cruiser OSR	
			Sumi alpha 5 FW (esfenvalerate)	06.06.13, 11.06.13, 19.06.13, 26.06.13		
	Lamminkylä	>1000m	Galera Avaunt Decis	01.06.13 04.06.13 15.06.13	Modesto (clothianidine, betacyfluthrin)	

Appendix 5. Weather data (daily) in the Trial fields 1-4 from the Observatory of Jokioinen in May 2013 – June 2015.

WEATHER CONDITIONS IN JOKIOINEN 2013. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

April

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-4.5	0.0	0.0	0.0	.	0.0	0.0	57
2	-2.5	0.0	5.1	-11.9	.	0.0	0.0	55
3	-1.9	0.0	5.0	-10.5	-16.3	0.0	0.0	55
4	-0.7	0.0	7.1	-8.8	.	0.0	0.0	59
5	-0.4	0.0	5.9	-9.5	-11.1	0.0	0.0	43
6	-2.1	0.0	3.3	-7.1	-11.3	0.0	0.0	42
7	-3.2	0.0	1.3	-9.2	-12.3	2.7	2.7	97
8	-4.7	0.0	1.4	-10.5	.	0.0	2.7	87
9	-3.1	0.0	4.5	-11.6	.	0.0	2.7	73
10	-2.7	0.0	5.6	-11.1	-11.4	0.0	2.7	55
11	-0.4	0.0	4.3	-7.6	-12.7	0.0	2.7	83
12	2.6	0.0	5.4	0.6	0.1	2.3	5.0	90
13	2.0	0.0	3.3	1.9	0.8	2.7	7.7	99
14	3.1	0.0	8.1	0.2	0.0	0.0	7.7	80
15	3.0	0.0	5.2	0.3	-1.5	4.4	12.1	94
16	4.5	0.0	6.0	3.4	2.0	0.4	12.5	85
17	5.8	0.0	9.6	3.9	3.1	0.3	12.8	80
18	5.4	0.0	8.3	2.2	1.3	8.7	21.5	96
19	4.7	0.0	5.7	4.1	3.1	0.6	22.1	96
20	4.3	0.0	7.9	1.9	0.9	0.0	22.1	46
21	4.6	0.0	11.1	-2.8	-6.1	0.0	22.1	45
22	5.6	0.6	11.0	-1.0	-4.9	0.0	22.1	41
23	5.1	0.7	8.7	1.4	2.2	1.4	23.5	95
24	6.5	2.2	11.6	1.4	0.0	0.1	23.6	47
25	5.7	2.9	11.2	0.7	-2.6	0.0	23.6	42
26	2.8	2.9	6.4	-1.1	-4.6	3.8	27.4	94
27	4.2	2.9	9.7	1.4	1.1	0.2	27.6	70
28	3.9	2.9	9.7	-1.0	-3.4	0.0	27.6	56
29	6.2	4.1	10.5	3.1	-0.5	4.8	32.4	80
30	5.2	4.3	7.7	3.3	2.8	1.0	33.4	74
Month	2.0					33.4		
Normal 1981-2010	*3.5*					*30.0*		

May

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	5.3	4.6	10.3	0.8	-1.2	0.0	0.0	32
2	5.4	5.0	9.9	0.0	-3.9	0.0	0.0	48
3	6.6	6.6	12.5	-1.3	-4.5	0.0	0.0	30
4	8.5	10.1	14.6	2.5	1.3	1.1	1.1	41
5	5.8	10.9	8.9	4.5	3.8	0.0	1.1	79
6	8.7	14.6	15.9	-2.4	-6.2	0.0	1.1	52
7	12.2	21.8	18.6	5.8	2.9	0.0	1.1	57
8	13.3	30.1	19.3	6.4	3.1	2.8	3.9	44
9	13.4	38.5	16.8	10.0	5.6	1.3	5.2	80
10	13.7	47.2	19.4	10.3	10.5	0.0	5.2	72
11	12.5	54.7	18.9	8.2	5.1	0.0	5.2	49
12	10.6	60.3	16.8	2.4	-0.8	0.0	5.2	48
13	11.7	67.0	18.2	2.7	-1.0	0.0	5.2	61
14	10.4	72.4	16.3	2.6	-1.9	0.0	5.2	87
15	9.8	77.2	15.9	3.5	-0.9	0.0	5.2	45
16	13.7	85.9	21.7	1.6	-2.4	0.0	5.2	28
17	17.1	98.0	23.9	8.3	2.6	0.0	5.2	80
18	16.3	109.3	20.2	11.2	7.2	0.0	5.2	78
19	19.1	123.4	24.1	13.3	10.7	0.0	5.2	65
20	15.8	134.2	17.6	13.6	10.4	0.0	5.2	78
21	17.3	146.5	22.5	12.2	7.6	0.0	5.2	47
22	12.7	154.2	14.1	11.3	7.9	6.5	11.7	96
23	10.4	159.6	11.1	9.5	9.5	4.5	16.2	95
24	12.4	167.0	17.3	9.7	9.4	0.0	16.2	75
25	15.0	177.0	20.5	7.6	2.4	0.0	16.2	40
26	16.2	188.2	22.0	11.5	6.0	1.7	17.9	76
27	15.8	199.0	20.1	12.2	11.2	0.0	17.9	65
28	17.6	211.6	22.9	11.3	6.3	0.0	17.9	40
29	18.5	225.1	.	11.5	4.8	0.0	17.9	41
30	18.0	238.1	22.9	11.7	6.9	0.0	17.9	76
31	17.4	250.5	22.0	11.5	7.1	0.2	18.1	57
Month	12.9					18.1		
Normal 1981-2010	*9.8*					*41.0*		

WEATHER CONDITIONS IN JOKIOINEN 2013. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

June

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	18.5	264.0	24.9	11.7	7.5	0.0	0.0	55
2	21.3	280.3	27.7	14.9	9.8	0.0	0.0	43
3	20.4	295.7	28.1	11.6	7.7	0.0	0.0	58
4	16.7	307.4	26.0	12.9	12.3	8.2	8.2	96
5	18.6	321.0	27.5	9.6	6.6	11.3	19.5	64
6	18.7	334.7	26.6	11.3	8.8	0.0	19.5	72
7	17.7	347.4	23.6	11.8	8.6	0.0	19.5	43
8	16.6	359.0	22.8	8.2	4.5	0.0	19.5	38
9	14.7	368.7	20.2	7.1	2.7	0.0	19.5	69
10	12.3	376.0	17.9	7.0	3.7	0.4	19.9	71
11	12.7	383.7	16.1	9.4	8.3	0.0	19.9	63
12	12.7	391.4	18.1	8.6	5.7	0.3	20.2	66
13	14.0	400.4	20.8	7.2	3.0	9.4	29.6	95
14	13.5	408.9	14.7	13.0	12.8	3.2	32.8	90
15	14.8	418.7	19.3	11.7	11.4	0.0	32.8	68
16	11.9	425.6	15.5	8.5	5.8	11.0	43.8	84
17	12.2	432.8	15.4	9.7	8.8	2.2	46.0	72
18	13.7	441.5	19.4	8.3	4.6	0.0	46.0	51
19	14.1	450.6	20.0	5.5	2.1	0.3	46.3	41
20	13.2	458.8	17.7	6.7	3.3	0.6	46.9	77
21	17.1	470.9	24.3	7.8	4.2	0.0	46.9	58
22	19.5	485.4	23.5	17.5	16.5	0.0	46.9	73
23	18.2	498.6	22.4	15.1	14.6	0.0	46.9	63
24	19.3	512.9	25.3	11.0	7.4	0.0	46.9	53
25	20.3	528.2	25.1	17.1	15.5	9.2	56.1	78
26	23.8	547.0	29.1	16.4	13.6	0.3	56.4	57
27	20.9	562.9	25.5	19.5	18.5	0.0	56.4	79
28	16.6	574.5	20.7	12.7	11.0	0.3	56.7	60
29	15.4	584.9	18.9	12.6	11.1	0.0	56.7	78
30	17.7	597.6	22.7	13.8	13.7	0.0	56.7	59
Month	16.6					56.7		
Normal 1981-2010	*14.0*					*63.0*		

July

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	16.1	608.7	23.1	9.6	5.2	14.4	14.4	92
2	15.8	619.5	20.4	11.5	10.8	2.2	16.6	64
3	16.0	630.5	20.2	13.0	10.9	0.3	16.9	53
4	15.9	641.4	21.8	7.2	3.4	0.0	16.9	89
5	19.9	656.3	25.0	14.1	11.2	0.5	17.4	77
6	17.1	668.4	20.5	15.9	15.3	0.0	17.4	63
7	17.9	681.3	23.9	9.1	5.7	0.0	17.4	49
8	15.5	691.8	20.4	10.3	7.1	0.4	17.8	58
9	16.0	702.8	22.1	7.3	3.5	1.2	19.0	45
10	15.9	713.7	18.7	13.4	12.5	2.0	21.0	96
11	15.2	723.9	20.8	9.6	7.3	0.0	21.0	59
12	16.1	735.0	22.3	6.6	3.0	0.0	21.0	48
13	18.8	748.8	25.6	9.3	5.9	0.0	21.0	47
14	17.7	761.5	25.3	10.5	7.3	0.0	21.0	85
15	15.1	771.6	21.4	7.5	3.9	0.0	21.0	62
16	14.0	780.6	17.0	10.7	9.9	0.0	21.0	51
17	14.9	790.5	20.1	9.2	7.7	0.0	21.0	55
18	12.9	798.4	15.7	9.9	7.3	10.9	31.9	90
19	12.8	806.2	16.5	8.3	4.9	1.8	33.7	77
20	13.6	814.8	19.1	9.1	7.6	0.2	33.9	72
21	14.1	823.9	18.8	10.2	9.7	0.0	33.9	60
22	13.7	832.6	16.7	9.6	8.4	0.0	33.9	81
23	16.8	844.4	21.2	13.4	13.2	0.0	33.9	74
24	16.1	855.5	18.3	13.4	11.9	0.0	33.9	83
25	18.0	868.5	25.7	9.9	6.7	0.0	33.9	66
26	17.7	881.2	26.4	13.0	9.7	13.0	46.9	94
27	19.5	895.7	27.3	9.7	7.2	0.0	46.9	60
28	19.2	909.9	27.0	11.3	8.4	0.0	46.9	70
29	18.4	923.3	22.7	11.4	6.8	2.8	49.7	94
30	18.6	936.9	23.5	15.7	15.3	1.2	50.9	75
31	18.3	950.2	21.6	15.3	15.1	4.6	55.5	71
Month	16.4					55.5		
Normal 1981-2010	*16.7*					*75.0*		

WEATHER CONDITIONS IN JOKIOINEN 2013. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

August

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	16.0	961.2	20.8	11.8	8.1	0.0	0.0	79
2	17.9	974.1	22.5	13.4	12.1	0.0	0.0	75
3	19.5	988.6	26.7	11.2	7.9	0.0	0.0	60
4	19.0	1002.6	25.8	11.6	8.7	0.5	0.5	65
5	19.0	1016.6	25.7	14.9	14.4	0.0	0.5	46
6	18.3	1029.9	25.8	9.4	5.8	0.0	0.5	43
7	18.5	1043.4	26.4	11.1	6.3	27.9	28.4	99
8	20.1	1058.5	25.1	17.5	15.7	0.9	29.3	84
9	18.3	1071.8	22.4	16.5	15.6	12.4	41.7	99
10	16.2	1083.0	19.2	15.1	14.8	5.3	47.0	96
11	15.4	1093.4	22.0	10.1	7.9	0.7	47.7	91
12	13.9	1102.3	18.4	8.6	6.5	8.2	55.9	75
13	15.1	1112.4	19.3	11.6	9.0	8.5	64.4	75
14	13.0	1120.4	14.5	12.1	11.7	18.9	83.3	97
15	15.1	1130.5	19.6	12.4	11.8	0.6	83.9	82
16	15.8	1141.3	21.0	10.0	8.2	0.0	83.9	64
17	15.5	1151.8	17.7	11.6	7.6	8.7	92.6	97
18	18.2	1165.0	22.2	14.2	12.2	4.6	97.2	79
19	17.2	1177.2	20.5	15.8	15.2	2.6	99.8	75
20	16.0	1188.2	21.9	11.9	7.7	0.0	99.8	61
21	15.9	1199.1	22.5	9.7	5.8	0.6	100.4	65
22	14.3	1208.4	19.9	12.4	9.4	1.3	101.7	66
23	12.2	1215.6	18.9	4.5	0.5	0.0	101.7	74
24	11.9	1222.5	19.8	3.7	0.7	0.0	101.7	74
25	13.8	1231.3	21.9	3.9	1.0	0.0	101.7	67
26	14.6	1240.9	22.9	5.8	2.2	0.0	101.7	68
27	15.1	1251.0	23.0	5.5	1.8	0.0	101.7	64
28	16.9	1262.9	22.7	10.0	3.9	0.0	101.7	73
29	12.3	1270.2	17.9	7.0	3.0	0.0	101.7	83
30	11.2	1276.4	17.2	7.0	4.4	1.0	102.7	77
31	13.2	1284.6	19.0	8.1	4.0	0.2	102.9	94
Month	15.8					102.9		
Normal 1981-2010	*15.0*					*80.0*		

September

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	at 3 p.m.
	° C	° C	° C	° C	° C	mm	mm	%
1	13.2	1292.8	18.5	11.0	5.9	3.0	3.0	93
2	9.8	1297.6	15.1	3.8	0.0	0.1	3.1	62
3	11.7	1304.3	19.2	4.5	0.3	0.0	3.1	60
4	12.6	1311.9	20.6	4.8	1.9	0.0	3.1	54
5	13.1	1320.0	21.3	4.4	1.4	0.0	3.1	46
6	13.4	1328.4	20.7	6.3	2.4	0.0	3.1	.
7	13.6	1337.0	21.4	5.1	1.1	0.0	3.1	52
8	14.5	1346.5	23.2	6.2	2.7	0.0	3.1	53
9	14.4	1355.9	21.0	7.7	4.9	5.6	8.7	60
10	13.2	1364.1	15.2	11.7	11.3	1.2	9.9	83
11	14.6	1373.7	18.9	11.3	8.9	0.0	9.9	87
12	14.0	1382.7	19.9	10.5	7.1	0.0	9.9	79
13	13.9	1391.6	20.9	7.8	5.3	0.0	9.9	67
14	12.8	1399.4	19.9	6.9	3.7	0.0	9.9	59
15	11.1	1405.5	15.9	5.6	0.8	0.0	9.9	66
16	12.0	1412.5	15.3	7.8	2.2	0.0	9.9	61
17	13.3	1420.8	15.4	11.5	10.6	0.0	9.9	65
18	13.6	1429.4	15.5	11.6	10.4	5.3	15.2	86
19	14.5	1438.9	15.9	13.4	12.9	1.6	16.8	95
20	13.4	1447.3	15.4	13.2	13.1	0.7	17.5	89
21	11.6	1453.9	15.8	8.6	5.6	0.0	17.5	72
22	9.8	1458.7	15.0	4.9	0.9	0.9	18.4	65
23	8.5	1462.2	12.2	6.3	5.0	2.0	20.4	84
24	5.6	1462.8	8.6	3.8	1.8	0.0	20.4	65
25	2.6	1462.8	7.3	-0.4	-2.0	0.0	20.4	54
26	2.8	1462.8	7.6	-1.3	-4.2	2.1	22.5	67
27	6.1	1463.9	10.0	3.8	1.0	0.0	22.5	82
28	6.4	1465.3	10.5	2.2	-2.7	0.0	22.5	71
29	5.8	1466.1	7.9	5.5	5.1	0.3	22.8	71
30	2.9	1466.1	6.0	-1.8	-5.7	0.0	22.8	56
Month	10.8					22.8		
Normal 1981-2010	*9.9*					*58.0*		

WEATHER CONDITIONS IN JOKIOINEN 2013. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

October

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	2.1	1465.9	5.4	-3.5	0.8	0.0	0.0	88
2	2.1	1465.9	8.5	-6.4	-10.3	0.0	0.0	79
3	6.9	1467.8	13.1	2.7	-1.7	0.0	0.0	86
4	7.5	1470.3	12.2	3.7	-2.0	0.0	0.0	80
5	9.8	1475.1	12.6	6.2	4.9	1.4	1.4	88
6	10.5	1480.6	13.7	9.1	8.7	0.0	1.4	83
7	10.0	1485.6	12.5	8.0	7.7	0.0	1.4	97
8	10.6	1491.2	12.5	6.6	1.7	8.8	10.2	99
9	11.8	1498.0	12.6	11.3	11.3	1.6	11.8	96
10	11.0	1504.0	13.3	8.3	10.2	2.5	14.3	99
11	6.0	1505.0	10.4	2.6	-0.8	0.0	14.3	90
12	5.8	1505.8	12.0	0.2	-2.7	0.0	14.3	94
13	7.2	1508.0	11.8	1.4	3.9	0.0	14.3	78
14	2.9	1508.0	9.3	-4.2	-8.1	0.0	14.3	87
15	7.4	1508.0	9.1	3.8	3.3	0.0	14.3	86
16	0.1	1508.0	7.4	-3.4	-8.0	0.0	14.3	93
17	1.8	1508.0	4.7	-4.0	-7.7	16.1	30.4	98
18	1.0	1508.0	5.1	-2.3	0.7	0.3	30.7	77
19	1.2	1508.0	4.7	-2.6	-6.7	0.3	31.0	75
20	-0.3	1508.0	5.2	-3.7	-9.5	0.0	31.0	88
21	-2.9	1508.0	4.7	-7.6	-13.0	0.0	31.0	93
22	-1.5	1508.0	3.0	-7.7	-12.5	9.0	40.0	73
23	7.9	1508.0	10.0	0.6	-0.1	6.3	46.3	99
24	10.2	1508.0	11.7	8.0	9.5	2.1	48.4	89
25	6.8	1508.0	9.9	2.9	6.2	0.0	48.4	86
26	6.3	1508.0	10.5	1.8	-1.8	9.2	57.6	100
27	10.1	1508.0	11.2	9.1	7.4	4.9	62.5	99
28	10.0	1508.0	10.9	9.1	9.2	16.9	79.4	95
29	8.8	1508.0	10.3	7.7	8.3	4.0	83.4	96
30	4.9	1508.0	8.0	0.8	4.0	0.0	83.4	97
31	3.7	1508.0	7.7	-0.3	-5.4	3.4	86.8	96
Month	5.8					86.8		
Normal								
1981-2010	*4.9*					*66.0*		

November

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	7.2	1508.0	8.1	5.9	6.3	4.8	4.8	96
2	5.5	1508.0	8.1	3.3	4.3	1.7	6.5	99
3	3.2	1508.0	6.3	1.9	-1.0	2.9	9.4	99
4	5.5	1508.0	6.4	1.9	1.9	6.5	15.9	97
5	5.5	1508.0	7.1	4.0	0.0	2.5	18.4	84
6	3.8	1508.0	6.8	2.2	2.8	0.0	18.4	95
7	3.2	1508.0	4.6	1.5	-1.3	3.9	22.3	96
8	3.9	1508.0	5.8	1.4	-1.9	1.3	23.6	92
9	5.8	1508.0	7.4	2.6	3.7	4.2	27.8	91
10	4.1	1508.0	6.2	1.5	2.2	2.2	30.0	96
11	0.9	1508.0	3.9	-1.6	-3.0	0.0	30.0	96
12	4.3	1508.0	6.4	-1.9	-7.8	4.0	34.0	97
13	4.7	1508.0	6.5	1.5	4.9	0.0	34.0	84
14	2.5	1508.0	4.9	0.3	-2.0	0.0	34.0	97
15	4.2	1508.0	6.2	0.0	-3.9	0.7	34.7	88
16	6.1	1508.0	8.7	4.7	3.6	0.0	34.7	94
17	4.6	1508.0	7.1	-0.6	2.7	0.0	34.7	64
18	2.7	1508.0	6.2	-1.2	-6.5	5.1	39.8	83
19	4.8	1508.0	6.0	2.9	2.2	11.1	50.9	95
20	2.3	1508.0	5.9	0.0	3.3	2.5	53.4	97
21	1.4	1508.0	3.6	0.1	-1.4	4.9	58.3	100
22	3.1	1508.0	5.7	0.0	1.9	0.0	58.3	92
23	0.3	1508.0	1.7	-0.6	-2.8	0.3	58.6	96
24	-0.8	1508.0	1.0	-2.9	-2.4	0.0	58.6	92
25	-3.4	1508.0	-0.9	-6.2	-10.7	0.0	58.6	92
26	-3.9	1508.0	1.9	-10	-14.2	1.2	59.8	92
27	2.7	1508.0	4.1	0.6	-0.5	1.2	61.0	95
28	2.4	1508.0	4.5	0.6	0.4	0.1	61.1	84
29	-3.3	1508.0	1.3	-7.7	-4.4	0.0	61.1	93
30	-1.9	1508.0	0.8	-7.7	-11.2	3.3	64.4	88
Month	2.7					64.4		
Normal								
1981-2010	*-0.2*					*57.0*		

WEATHER CONDITIONS IN JOKIOINEN 2013. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

December

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-0.3	1508.0	1.9	-4.7	-7.7	0.9	0.9	79
2	-3.0	1508.0	1.5	-6.2	-8.3	0.1	1.0	79
3	2.2	1508.0	3.6	-2.1	0.1	0.0	1.0	85
4	-4.2	1508.0	3.5	-7.8	-11.1	0.0	1.0	95
5	-0.5	1508.0	1.3	-7.5	-13.9	3.1	4.1	95
6	0.4	1508.0	1.5	-1.2	-1.2	4.5	8.6	100
7	-2.6	1508.0	-0.1	-5.2	-2.9	0.7	9.3	93
8	-5.6	1508.0	-4.3	-6.4	,	0.0	9.3	92
9	-8.8	1508.0	-5.4	-16.5	,	0.0	9.3	92
10	-5.6	1508.0	1.7	-17.3	-22.7	4.0	13.3	100
11	1.1	1508.0	1.7	0.9	0.6	0.8	14.1	100
12	2.6	1508.0	6.4	0.9	0.6	1.7	15.8	95
13	0.5	1508.0	6.8	-5.2	1.0	0.0	15.8	79
14	-5.6	1508.0	-2.4	-7.6	-11.7	1.4	17.2	92
15	0.6	1508.0	3.4	-4.8	-4.9	1.8	19.0	100
16	3.6	1508.0	5.3	2.2	1.9	2.4	21.4	98
17	3.4	1508.0	6.9	0.3	2.9	0.0	21.4	95
18	-0.2	1508.0	1.9	-0.9	-5.0	0.0	21.4	100
19	1.4	1508.0	2.1	0.0	-0.2	2.4	23.8	99
20	2.4	1508.0	4.0	1.0	0.4	0.5	24.3	90
21	3.1	1508.0	5.5	1.6	1.3	2.7	27.0	96
22	4.9	1508.0	5.6	4.0	3.1	4.1	31.1	80
23	2.8	1508.0	4.8	1.0	2.3	4.0	35.1	92
24	3.0	1508.0	5.6	0.8	-0.5	7.4	42.5	96
25	4.9	1508.0	5.7	3.9	4.1	3.2	45.7	95
26	4.6	1508.0	5.5	3.2	3.5	0.2	45.9	94
27	3.5	1508.0	5.1	2.3	2.2	7.1	53.0	96
28	4.9	1508.0	5.2	4.1	3.6	7.6	60.6	95
29	4.0	1508.0	5.1	3.2	2.7	0.5	61.1	90
30	2.1	1508.0	4.0	-0.7	2.0	0.3	61.4	95
31	2.9	1508.0	4.2	-0.9	-3.0	0.1	61.5	92
Month	0.7					61.5		
Normal								
1981-2010	*-3.9*					*47.0*		

WEATHER CONDITIONS IN JOKIOINEN 2014. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

January

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	3.0	0.0	,	,	3.2	1.2	1.2	83
2	-0.2	0.0	,	,	-0.2	0.0	1.2	91
3	0.1	0.0	,	,	-0.9	0.3	1.5	94
4	0.8	0.0	,	,	0.1	5.0	6.5	97
5	3.2	0.0	,	,	0.0	0.0	6.5	97
6	1.1	0.0	,	,	0.3	1.0	7.5	100
7	2.8	0.0	,	,	1.3	10.0	17.5	96
8	4.6	0.0	,	,	0.2	2.4	19.9	98
9	2.4	0.0	,	,	3.1	1.5	21.4	99
10	0.0	0.0	,	,	0.0	1.5	22.9	95
11	-4.4	0.0	,	,	-4.2	1.7	24.6	94
12	-9.5	0.0	,	,	-11.9	0.1	24.7	87
13	-14.7	0.0	,	,	-17.4	0.0	24.7	87
14	-18.2	0.0	,	,	-25.5	0.0	24.7	85
15	-14.5	0.0	,	,	-23.8	0.0	24.7	89
16	-15.5	0.0	,	,	-22.9	0.0	24.7	86
17	-16.2	0.0	,	,	-24.9	0.0	24.7	86
18	-16.7	0.0	,	,	-23.6	0.0	24.7	86
19	-17.8	0.0	,	,	-26.2	0.0	24.7	86
20	-18.2	0.0	,	,	-25.2	0.0	24.7	86
21	-14.5	0.0	,	,	-24.4	0.0	24.7	84
22	-16.9	0.0	,	,	-23.7	0.0	24.7	86
23	-19.1	0.0	,	,	-23.5	0.0	24.7	83
24	-20.8	0.0	,	,	-26.2	0.0	24.7	83
25	-9.4	0.0	,	,	-24.5	0.0	24.7	85
26	-8.4	0.0	,	,	-7.9	0.0	24.7	90
27	-9.3	0.0	,	,	-10.4	0.0	24.7	86
28	-10.1	0.0	,	,	-12.1	0.0	24.7	87
29	-11.5	0.0	,	,	-15.9	0.0	24.7	86
30	-12.5	0.0	,	,	-17.5	0.0	24.7	80
31	-11.7	0.0	,	,	-18.5	1.7	26.4	74
Month	-8.8					26.4		
Normal 1981-2010	*-5.6*					*46.0*		

February

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-6.9	0.0	,	,	-9.3	1.4	1.4	95
2	-4.0	0.0	,	,		2.3	3.7	93
3	-0.4	0.0	,	,	-3.6	0.3	4.0	100
4	-0.4	0.0	,	,	-0.3	0.0	4.0	100
5	-3.7	0.0	,	,	-3.5	0.0	4.0	93
6	-4.9	0.0	,	,	-11.0	0.1	4.1	94
7	-0.9	0.0	,	,	-4.6	2.0	6.1	100
8	1.3	0.0	,	,	0.3	2.0	8.1	97
9	1.6	0.0	,	,	0.4	0.3	8.4	90
10	1.1	0.0	,	,	0.5	3.0	11.4	100
11	0.2	0.0	,	,	0.0	0.8	12.2	100
12	0.1	0.0	,	,	-0.7	0.3	12.5	100
13	0.4	0.0	,	,	0.0	0.6	13.1	90
14	-0.2	0.0	,	,	-0.7	0.3	13.4	93
15	-0.6	0.0	,	,	-1.1	0.4	13.8	85
16	0.9	0.0	,	,	-1.2	2.1	15.9	99
17	1.3	0.0	,	,	0.8	0.7	16.6	100
18	0.4	0.0	,	,	0.0	0.4	17.0	90
19	0.0	0.0	,	,	-1.4	0.2	17.2	94
20	-2.3	0.0	,	,	-2.0	0.1	17.3	90
21	-2.6	0.0	,	,	-4.5	2.9	20.2	90
22	1.6	0.0	,	,	-1.3	2.5	22.7	96
23	2.8	0.0	,	,	1.0	0.3	23.0	90
24	3.8	0.0	,	,	1.1	0.0	23.0	83
25	1.7	0.0	,	,	0.7	0.0	23.0	91
26	-0.7	0.0	,	,	-7.0	0.0	23.0	84
27	0.1	0.0	,	,	-0.9	0.0	23.0	86
28	0.1	0.0	,	,	-0.9	0.0	23.0	96
Month	-0.4					23.0		
Normal 1981-2010	*-6.3*					*32.0*		

WEATHER CONDITIONS IN JOKIOINEN 2014. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

March

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	0.0	0.0	2.8	-1.3	,	0.0	0.0	82
2	-0.1	0.0	0.8	-0.8	-2.9	2.6	2.6	99
3	0.6	0.0	1.2	0.2	-2.9	0.8	3.4	97
4	0.8	0.0	1.7	0.0	-0.1	0.0	3.4	98
5	0.9	0.0	2.8	-1.5	-0.4	0.0	3.4	89
6	0.0	0.0	3.0	-3.4	0.0	0.0	3.4	94
7	2.1	0.0	3.0	1.2	-8.5	10.2	13.6	85
8	3.5	0.0	6.2	1.6	0.1	1.3	14.9	64
9	3.7	0.0	6.0	1.4	0.0	0.0	14.9	87
10	4.2	0.0	6.8	1.5	-1.7	3.4	18.3	98
11	3.2	0.0	6.1	0.6	1.0	0.0	18.3	78
12	4.0	0.0	9.4	-1.0	-2.1	0.0	18.3	76
13	4.5	0.0	9.9	1.1	-6.4	0.0	18.3	63
14	3.4	0.0	5.6	1.4	-4.2	6.4	24.7	68
15	0.2	0.0	1.4	-0.4	-0.4	1.6	26.3	73
16	-3.1	0.0	-1.1	-7.7	-1.8	0.3	26.6	66
17	-7.1	0.0	-1.4	-13.4	-6.0	0.0	26.6	62
18	-3.2	0.0	0.7	-5.5		1.2	27.8	90
19	-4.4	0.0	-1.7	-10.3	-10.7	0.0	27.8	53
20	-6.2	0.0	0.3	-13.7	-6.3	3.2	31.0	96
21	5.3	0.0	7.9	3.6	-21.0	0.5	31.5	73
22	2.9	0.0	6.0	0.6	-2.1	0.0	31.5	87
23	2.1	0.0	4.3	0.5	-1.4	0.4	31.9	89
24	3.2	0.0	8.4	-1.5	-0.4	0.0	31.9	80
25	2.3	0.0	6.8	-4.3	-4.6	0.0	31.9	43
26	2.2	0.0	7.5	-2.3	-9.6	0.0	31.9	43
27	2.4	0.0	11.5	-5.9	-3.8	0.0	31.9	41
28	2.6	0.0	8.7	-3.0	-11.8	0.0	31.9	56
29	3.7	0.0	9.5	-2.4	-8.2	0.0	31.9	62
30	2.1	0.0	6.5	-2.8	-7.7	0.0	31.9	57
31	-0.5	0.0	2.9	-2.0	-7.9	0.0	31.9	62
Month	1.1				-7.2	31.9		
Normal 1981-2010	*-2.4*					*32.0*		

April

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-1.5	0.0	2.6	-5.0	-9.9	0.2	0.2	55
2	-0.2	0.0	6.0	-8.1	-12.6	0.0	0.2	57
3	1.2	0.0	6.1	-1.2	-3.0	0.0	0.2	49
4	-0.1	0.0	6.1	-6.4	-11.4	0.0	0.2	42
5	3.0	0.0	9.3	-3.5	-7.5	0.9	1.1	57
6	3.2	0.0	6.1	0.8	-0.7	1.4	2.5	91
7	2.7	0.0	5.2	-0.8	-4.7	2.2	4.7	96
8	2.7	0.0	9.0	-2.0	-3.8	0.0	4.7	55
9	1.7	0.0	6.8	-3.0	-7.3	0.0	4.7	34
10	1.1	0.0	5.9	-4.7	-8.7	0.0	4.7	49
11	3.0	0.0	4.7	-0.4	-3.6	4.5	9.2	96
12	3.7	0.0	8.2	1.6	1.9	2.0	11.2	90
13	4.3	0.0	5.7	2.2	1.3	1.7	12.9	94
14	3.9	0.0	9.0	3.0	2.6	7.6	20.5	95
15	3.7	0.0	9.2	-0.3	-4.2	2.2	22.7	56
16	3.4	0.0	9.8	-3.9	-8.9	0.0	22.7	49
17	5.6	0.6	11.2	0.9	-0.9	0.0	22.7	68
18	7.7	3.3	13.1	3.9	2.7	0.0	22.7	54
19	6.8	5.1	14.5	-2.2	-6.8	0.0	22.7	54
20	9.6	9.7	18.3	-2.3	-7.3	0.0	22.7	57
21	11.9	16.6	19.5	2.3	-3.0	0.0	22.7	36
22	11.3	22.9	18.3	3.8	-2.0	0.0	22.7	39
23	4.7	22.9	10.3	-0.8	-4.4	0.0	22.7	30
24	5.0	22.9	13.4	-5.4	-10.5	0.0	22.7	32
25	7.6	25.5	16.6	-4.2	-10.2	0.0	22.7	30
26	8.2	28.7	17.4	-3.2	-9.5	0.0	22.7	31
27	9.9	33.6	18.5	-1.4	-6.6	0.0	22.7	37
28	10.1	38.7	18.0	-1.1	-6.1	0.0	22.7	36
29	6.4	40.1	10.5	2.8	-1.3	0.0	22.7	48
30	4.4	40.1	10.3	-1.9	-7.0	0.6	23.3	41
Month	4.8					23.3		
Normal 1981-2010	*3.5*					*30.0*		

WEATHER CONDITIONS IN JOKIOINEN 2014. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

May

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp.sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	1.9	40.1	6.7	-2.7	-7.9	3.0	3.0	86
2	3.3	40.1	8.4	-3.3	-8.5	0.7	3.7	57
3	3.4	40.1	10.0	-2.8	-8.8	0.0	3.7	41
4	1.6	40.1	8.5	-4.6	-10.0	4.1	7.8	55
5	3.8	40.1	9.7	-0.8	-2.2	0.0	7.8	42
6	3.3	40.1	9.2	-3.1	-9.7	0.0	7.8	31
7	4.9	40.1	11.4	-5.4	-11.0	0.0	7.8	26
8	3.8	40.1	4.5	2.2	0.1	6.7	14.5	95
9	8.6	43.7	12.7	4.1	4.1	7.1	21.6	82
10	8.5	47.2	12.0	5.1	5.7	0.0	21.6	79
11	9.8	52.0	14.2	6.4	3.2	3.1	24.7	71
12	8.9	55.9	11.9	6.8	4.2	0.0	24.7	85
13	7.8	58.7	10.1	5.6	2.4	0.0	24.7	83
14	8.4	62.1	12.5	5.7	5.1	0.0	24.7	40
15	6.0	63.1	11.7	-2.5	-7.9	0.0	24.7	35
16	9.2	67.3	15.0	4.2	0.1	0.4	25.1	56
17	12.5	74.8	20.1	0.8	-3.6	0.0	25.1	37
18	16.9	86.7	24.7	4.9	-1.6	0.0	25.1	26
19	19.4	101.1	29.1	12.0	5.8	3.0	28.1	46
20	16.3	112.4	21.1	12.8	8.6	0.0	28.1	63
21	15.4	122.8	21.3	7.7	2.3	0.0	28.1	55
22	17.8	135.6	25.2	8.0	2.9	0.0	28.1	38
23	21.4	152.0	28.2	10.4	4.0	0.0	28.1	35
24	23.3	170.3	28.9	16.0	8.5	0.0	28.1	33
25	20.9	186.2	26.6	14.6	8.7	0.2	28.3	59
26	14.1	195.3	20.0	11.5	8.8	0.0	28.3	59
27	6.1	196.4	7.1	5.9	6.6	2.0	30.3	93
28	7.0	198.4	9.0	4.1	2.6	0.0	30.3	75
29	9.0	202.4	11.7	7.5	6.2	5.3	35.6	94
30	11.6	209.0	16.2	8.8	8.8	0.1	35.7	74
31	10.4	214.4	12.5	8.7	8.5	5.1	40.8	90
Month	10.2					40.8		
Normal 1981-2010	*9.8*					*41.0*		

June

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	10.5	219.9	14.9	6.6	.	0.0	0.0	79
2	14.8	229.7	20.2	7.2	2.0	0.0	0.0	51
3	14.6	239.3	17.1	12.9	11.0	3.9	3.9	78
4	19.6	253.9	25.0	13.2	9.3	0.0	3.9	63
5	22.0	270.9	27.5	14.6	8.9	10.1	14.0	37
6	17.4	283.3	21.7	13.6	11.0	4.7	18.7	94
7	15.3	293.6	19.3	11.4	8.9	0.0	18.7	80
8	16.0	304.6	20.6	10.6	5.8	0.0	18.7	60
9	16.5	316.1	23.3	7.4	2.9	0.0	18.7	56
10	14.6	325.7	17.2	13.3	13.0	0.0	18.7	83
11	16.5	337.2	23.3	6.4	1.8	8.5	27.2	38
12	13.2	345.4	13.8	12.9	12.7	12.6	39.8	95
13	12.4	352.8	16.5	10.5	10.0	1.4	41.2	85
14	10.3	358.1	14.8	8.6	9.0	0.0	41.2	65
15	12.9	366.0	19.8	2.1	-1.9	0.0	41.2	43
16	9.4	370.4	16.2	5.4	0.4	1.2	42.4	71
17	7.4	372.8	11.8	3.9	2.0	0.6	43.0	34
18	11.0	378.8	15.8	4.6	2.9	0.1	43.1	74
19	11.5	385.3	16.3	7.7	4.6	1.1	44.2	64
20	9.8	390.1	14.6	5.4	1.3	2.1	46.3	58
21	6.8	391.9	12.0	2.6	-1.1	2.7	49.0	82
22	6.7	393.6	10.3	2.3	-1.0	15.1	64.1	87
23	9.1	397.7	13.0	6.2	6.2	1.2	65.3	67
24	11.3	404.0	15.7	8.4	7.7	9.1	74.4	73
25	10.6	409.6	13.8	6.4	4.8	0.0	74.4	54
26	11.9	416.5	16.4	8.2	7.6	0.0	74.4	47
27	11.6	423.1	16.6	6.1	1.5	1.2	75.6	77
28	13.1	431.2	18.8	5.8	1.2	0.1	75.7	54
29	11.4	437.6	13.2	9.7	6.8	2.9	78.6	94
30	12.1	444.7	14.2	10.7	10.6	0.4	79.0	90
Month	12.7					79.0		
Normal 1981-2010	*14.0*					*63.0*		

WEATHER CONDITIONS IN JOKIOINEN 2014. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

July

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp.sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	12.3	452.0	14.3	10.7	10.7	4.9	4.9	75
2	11.7	458.7	14.5	10.4	9.6	2.3	7.2	80
3	15.2	468.9	20.8	9.6	8.9	0.4	7.6	57
4	16.0	479.9	20.7	12.9	12.6	0.0	7.6	55
5	16.0	490.9	22.8	6.9	2.9	0.0	7.6	58
6	18.3	504.2	24.1	9.7	5.9	0.0	7.6	38
7	20.2	519.4	26.4	10.0	4.7	0.0	7.6	59
8	21.2	535.6	27.3	13.2	8.5	0.0	7.6	41
9	21.3	551.9	28.1	11.5	7.6	0.0	7.6	45
10	18.3	565.2	22.3	15.2	10.8	0.0	7.6	63
11	15.7	575.9	21.3	7.0	1.5	0.0	7.6	42
12	16.2	587.1	21.1	8.4	4.2	0.0	7.6	57
13	20.8	602.9	26.4	15.5	11.0	0.0	7.6	60
14	18.9	616.8	22.2	16.2	12.5	0.0	7.6	78
15	17.2	629.0	20.9	12.4	7.5	6.5	14.1	89
16	16.8	640.8	20.8	15.1	14.3	6.5	20.6	84
17	19.1	654.9	24.4	12.8	9.3	0.0	20.6	61
18	19.0	668.9	24.8	11.4	8.0	0.0	20.6	60
19	18.2	682.1	25.3	11.6	8.9	0.0	20.6	57
20	18.2	695.3	25.1	11.4	8.6	5.0	25.6	95
21	20.1	710.4	25.8	13.0	9.1	0.0	25.6	49
22	20.5	725.9	27.3	11.0	7.2	0.0	25.6	42
23	22.3	743.2	29.0	13.3	9.7	0.0	25.6	37
24	23.5	761.7	30.7	15.5	11.8	0.0	25.6	42
25	23.7	780.4	30.4	15.0	11.0	0.0	25.6	43
26	23.0	798.4	30.2	14.4	11.0	0.0	25.6	35
27	22.8	816.2	29.5	12.0	8.0	0.0	25.6	39
28	22.7	833.9	29.5	16.9	12.8	0.1	25.7	46
29	21.5	850.4	28.4	15.8	11.9	1.9	27.6	65
30	21.1	866.5	28.6	14.1	11.8	9.4	37.0	48
31	20.9	882.4	26.9	17.6	14.9	4.0	41.0	88
Month	19.1					41.0		
Normal 1981-2010	*16.7*					*75.0*		

August

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm		%
1	19.6	897.0	24.3	15.5	11.6	0.1	0.1	50
2	20.6	912.6	26.2	15.2	12.2	0.2	0.3	50
3	21.6	929.2	27.3	14.0	10.0	0.0	0.3	52
4	23.6	947.8	29.3	17.5	13.9	0.0	0.3	40
5	23.5	966.3	29.5	16.9	13.0	0.0	0.3	37
6	23.6	984.9	30.2	15.7	10.1	0.0	0.3	31
7	19.9	999.8	28.4	17.9	14.6	12.1	12.4	93
8	20.2	1015.0	26.3	14.3	10.3	0.0	12.4	42
9	18.5	1028.5	26.1	11.1	7.3	2.5	14.9	51
10	19.2	1042.7	26.1	12.4	8.5	0.1	15.0	56
11	19.6	1057.3	25.7	14.9	11.7	11.7	26.7	56
12	18.5	1070.8	22.5	16.1	15.7	4.9	31.6	50
13	15.2	1081.0	20.6	11.4	6.9	5.0	36.6	75
14	16.5	1092.5	21.7	11.9	7.8	0.0	36.6	65
15	15.8	1103.3	21.4	13.3	12.3	10.7	47.3	78
16	15.0	1113.3	21.6	9.2	6.8	0.0	47.3	61
17	14.8	1123.1	21.1	7.1	2.9	3.9	51.2	45
18	14.0	1132.1	16.5	11.9	7.5	26.1	77.3	94
19	13.5	1140.6	17.2	11.0	10.4	9.0	86.3	78
20	13.2	1148.8	16.5	10.5	6.4	2.2	88.5	76
21	14.4	1158.2	17.9	11.4	10.6	0.0	88.5	63
22	12.7	1165.9	17.5	9.6	4.6	2.4	90.9	73
23	12.6	1173.5	17.3	9.3	5.3	3.7	94.6	65
24	13.3	1181.8	17.6	10.3	6.9	0.9	95.5	68
25	10.9	1187.7	14.5	5.2	2.1	17.5	113.0	89
26	13.4	1196.1	17.7	12.1	11.8	8.2	121.2	95
27	13.6	1204.7	17.8	12.0	11.6	4.3	125.5	92
28	13.8	1213.5	18.3	12.4	11.6	1.3	126.8	70
29	11.5	1220.0	15.7	8.9	5.6	1.6	128.4	86
30	10.2	1225.2	15.3	5.6	1.9	0.0	128.4	52
31	11.0	1231.2	15.6	8.2	6.3	0.0	128.4	60
Month	16.3					128.4		
Normal 1981-2010	*15.0*					*80.0*		

WEATHER CONDITIONS IN JOKIOINEN 2014. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute.*

September

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp.sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	9.4	1235.6	14.9	3.1	0.5	0.0	0.0	63
2	11.8	1242.4	15.8	5.3	1.3	0.0	0.0	70
3	15.5	1252.9	21.4	10.7	9.5	0.0	0.0	64
4	15.6	1263.5	21.8	12.3	8.5	0.0	0.0	63
5	15.2	1273.7	21.8	11.6	10.4	0.0	0.0	58
6	13.2	1281.9	19.7	7.3	3.0	0.0	0.0	62
7	11.9	1288.8	20.0	5.7	2.9	0.0	0.0	57
8	14.7	1298.5	22.0	5.7	2.4	0.0	0.0	59
9	15.0	1308.5	17.4	13.1	9.6	2.9	2.9	94
10	13.6	1317.1	19.0	11.6	12.0	0.0	2.9	76
11	12.7	1324.8	20.9	6.2	4.4	0.2	3.1	58
12	12.1	1331.9	16.6	6.9	3.4	0.0	3.1	88
13	11.5	1338.4	17.5	8.6	4.0	0.0	3.1	60
14	10.4	1343.8	19.0	3.2	0.1	0.0	3.1	49
15	10.8	1349.6	18.8	6.8	2.5	0.0	3.1	52
16	10.2	1354.8	17.4	1.1	-2.2	0.0	3.1	70
17	11.2	1361.0	18.3	7.3	3.6	0.0	3.1	64
18	10.2	1366.2	18.6	2.9	0.7	0.0	3.1	62
19	11.7	1372.9	19.2	4.6	0.8	0.0	3.1	59
20	13.9	1381.8	19.1	7.5	2.4	0.0	3.1	71
21	13.7	1390.5	17.2	10.8	5.4	4.1	7.2	78
22	7.5	1393.0	12.1	10.6	7.6	14.0	21.2	98
23	2.8	1393.0	.	0.5	-0.4	0.0	21.2	48
24	4.2	1393.0	9.1	-0.8	-2.6	1.1	22.3	52
25	8.5	1396.5	11.0	4.4	4.1	0.2	22.5	87
26	11.3	1402.8	13.9	7.5	4.2	5.6	28.1	78
27	9.8	1407.6	13.3	7.2	5.4	0.0	28.1	61
28	11.7	1414.3	16.9	8.2	5.6	0.0	28.1	65
29	9.9	1419.2	14.6	6.5	2.5	0.0	28.1	49
30	6.9	1421.1	11.9	5.0	3.0	0.0	28.1	58
Month	11.2					28.1		
Normal 1981-2010	*9.9*					*58.0*		

October

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	3.7	1421.1	12.1	-2.9	-7.0	0.0	0.0	54
2	8.5	1424.6	12.8	0.7	-4.7	0.5	0.5	62
3	10.9	1430.5	12.8	9.5	9.5	0.3	0.8	96
4	11.8	1437.3	14.5	10.9	10.5	0.0	0.8	87
5	6.8	1439.1	8.8	5.3	3.4	0.0	0.8	80
6	5.7	1439.8	7.1	3.9	3.2	0.0	0.8	75
7	7.3	1442.1	9.5	4.7	4.4	0.0	0.8	65
8	7.5	1444.6	9.6	6.1	4.9	6.2	7.0	97
9	10.2	1449.8	12.3	9.1	6.6	4.1	11.1	83
10	11.9	1456.7	12.8	9.6	9.3	0.0	11.1	94
11	10.0	1461.7	12.7	10.0	8.6	0.0	11.1	83
12	7.3	1464.0	9.2	4.2	-0.9	0.7	11.8	89
13	7.6	1466.6	9.0	6.6	6.0	0.0	11.8	87
14	7.7	1469.3	9.7	6.9	6.9	0.0	11.8	87
15	2.3	1469.3	2.2	1.8	1.4	0.0	11.8	78
16	0.8	1469.3	4.0	-0.8	-1.6	0.0	11.8	69
17	-1.1	1469.3	3.7	-4.8	-10.5	0.0	11.8	60
18	0.1	1469.3	4.4	-6.5	-11.4	5.4	17.2	59
19	6.9	1471.2	10.0	2.4	1.5	4.4	21.6	99
20	4.8	1471.2	4.7	4.7	4.9	0.2	21.8	98
21	-0.2	1471.2	0.6	0.0	-0.9	0.0	21.8	77
22	-3.3	1471.2	-1.2	-4.5	-5.8	0.0	21.8	58
23	-4.2	1471.2	-1.7	-6.6	-8.4	0.0	21.8	79
24	-0.4	1471.2	1.4	-4.6	-6.6	0.9	22.7	70
25	3.5	1471.2	4.5	1.4	0.8	0.8	23.5	91
26	7.5	1473.7	10.1	4.1	3.3	0.8	24.3	93
27	10.8	1479.5	11.5	10.0	9.2	2.2	26.5	92
28	11.3	1485.8	12.1	10.6	9.5	0.3	26.8	91
29	8.2	1489.0	10.3	8.2	7.0	1.0	27.8	88
30	4.3	1489.0	7.9	3.2	0.9	0.0	27.8	78
31	3.5	1489.0	6.2	0.3	-5.3	0.0	27.8	76
Month	5.5					27.8		
Normal 1981-2010	*4.9*					*66.0*		

WEATHER CONDITIONS IN JOKIOINEN 2014. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute*

November

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-0.1	1489.0	4.4	-1.5	-0.5	2.8	2.8	69.0
2	6.7	1489.0	9.6	-0.4	-0.4	0.4	3.2	100.0
3	9.6	1489.0	1.0	8.8	8.7	1.9	5.1	99.0
4	9.5	1489.0	10.3	0.9	8.3	6.1	11.2	94.0
5	0.7	1489.0	9.8	-1.6	-0.7	0.0	11.2	76.0
6	-0.7	1489.0	0.4	-0.3	-4.1	12.4	23.6	100.0
7	0.1	1489.0	0.4	-0.3	-0.5	0.5	24.1	100.0
8	-0.4	1489.0	0.3	-0.1	-0.5	0.0	24.1	98.0
9	4.6	1489.0	6.9	-0.1	-1.7	0.0	24.1	100.0
10	5.2	1489.0	7.5	3.8	4.6	2.5	26.6	100.0
11	7.9	1489.0	9.2	4.5	4.4	0.3	26.9	95.0
12	4.6	1489.0	7.9	3.4	3.8	0.0	26.9	97.0
13	1.4	1489.0	3.6	0.6	0.7	0.0	26.9	95.0
14	0.8	1489.0	1.2	0.2	0.0	0.0	26.9	96.0
15	0.2	1489.0	0.9	-0.1	0.0	0.0	26.9	96.0
16	0.9	1489.0	2.5	-0.2	-0.3	0.0	26.9	97.0
17	0.5	1489.0	0.1	-0.2	-1.8	0.0	26.9	89.0
18	0.2	1489.0	1.1	-0.8	-0.3	0.0	26.9	98.0
19	-0.8	1489.0	-0.1	-1.6	-1.3	0.0	26.9	85.0
20	-1.3	1489.0	-0.6	-2.7	-4.7	0.0	26.9	95.0
21	-1.8	1489.0	-0.9	-2.3	-0.2	6.8	33.7	99.0
22	-2.4	1489.0	-1.7	-2.9	.	0.0	33.7	98.0
23	-0.8	1489.0	0.3	-0.3	.	0.4	34.1	100.0
24	0.7	1489.0	1.9	-0.3	-0.4	0.3	34.4	91.0
25	2.7	1489.0	3.6	0.4	0.2	1.3	35.7	100.0
26	2.8	1489.0	0.4	2.1	1.4	0.6	36.3	100.0
27	2.7	1489.0	3.2	2.2	2.2	3.6	39.9	100.0
28	2.2	1489.0	2.7	1.9	2.1	0.5	40.4	99.0
29	1.4	1489.0	1.9	0.5	0.0	0.2	40.6	100.0
30	-1.3	1489.0	1.3	-3.1	-1.2	0.1	40.7	90.0
Month	1.9					40.7		
Normal 1981-2010	*-0.2*					*57.0*		

December

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-5.4	1489.0	-2.8	-6.7	-10.9	0.0	0.0	93
2	-0.1	1489.0	2.5	-7.2	-11.6	0.4	0.4	87
3	1.3	1489.0	3.1	0.6	-0.7	0.0	0.4	94
4	1.3	1489.0	4.2	-1.1	-0.6	0.1	0.5	100
5	0.7	1489.0	3.2	-2.6	-6.5	4.5	5.0	99
6	1.3	1489.0	2.5	0.2	0.0	1.2	6.2	98
7	2.3	1489.0	4.3	-0.1	-7.2	4.4	10.6	91
8	3.4	1489.0	4.6	2.4	3.3	5.1	15.7	100
9	2.1	1489.0	2.8	1.7	-0.7	0.0	15.7	87
10	2.2	1489.0	3.8	0.1	-0.4	0.8	16.5	95
11	2.1	1489.0	3.6	0.4	0.0	15.8	32.3	96
12	1.6	1489.0	2.1	0.6	0.0	4.8	37.1	98
13	0.0	1489.0	1.6	-0.8	-0.1	0.2	37.3	100
14	0.0	1489.0	0.6	-1.1	-0.5	0.1	37.4	100
15	1.9	1489.0	2.9	-0.8	-0.2	5.7	43.1	96
16	0.1	1489.0	2.5	-0.2	0.2	5.1	48.2	92
17	0.2	1489.0	1.8	-0.1	-1.9	0.4	48.6	100
18	-0.3	1489.0	0.8	-2.6	-6.4	3.3	51.9	99
19	0.2	1489.0	3.2	0.7	-0.1	2.1	54.0	94
20	0.0	1489.0	1.8	-1.3	-1.9	0.3	54.3	95
21	-0.1	1489.0	-0.1	-2.3	-4.2	0.4	54.7	84
22	-3.6	1489.0	-0.5	-5.5	-7.1	0.2	54.9	96
23	-6.7	1489.0	-3.7	-8.1	-10.4	0.6	55.5	92
24	-7.8	1489.0	-5.9	-1.0	.	3.7	59.2	93
25	-1.2	1489.0	-6.8	-16.6	.	0.1	59.3	90
26	-4.7	1489.0	-2.2	-12.5	.	1.1	60.4	94
27	-7.2	1489.0	-0.6	-9.2	.	0.0	60.4	87
28	-11.3	1489.0	-6.8	-13.1	.	0.0	60.4	90
29	-18.3	1489.0	[illegible]	-23.7	.	1.5	61.9	90
30	-0.8	1489.0	0.1	-12.5	.	6.6	68.5	100
31	3.4	1489.0	0.4	0.1	-0.1	0.2	68.7	95
Month	-1.4					68.7		
Normal 1981-2010	*-3.9*					*47.0*		

WEATHER CONDITIONS IN JOKIOINEN 2015. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute*

January

	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	0.2	0.0	4.5	0.4	-0.1	2.1	2.1	100
2	2.9	0.0	4.7	2.1	-0.1	15.4	17.5	88
3	0.5	0.0	2.6	-0.4	0.0	9.7	27.2	100
4	-1.7	0.0	-0.4	-2.3	.	0.6	27.8	94
5	-12.2	0.0	-2.3	-16.3	.	0.0	27.8	89
6	-16.5	0.0	-10.3	-22.2	.	0.3	28.1	88
7	-0.3	0.0	-1.2	-10.3	.	0.2	28.3	95
8	0.5	0.0	2.5	-2.7	.	0.5	28.8	99
9	-0.1	0.0	2.5	-0.7	-0.2	0.2	29.0	98
10	-2.6	0.0	0.2	-3.5	-0.5	2.1	31.1	88
11	-0.8	0.0	-1.6	-12.4	-5.1	0.3	31.4	84
12	-12.1	0.0	-11.5	-15.9	-12.2	4.3	35.7	89
13	-0.6	0.0	1.3	-12.3	-11.9	4.6	40.3	93
14	0.5	0.0	1.6	-0.9	-5.6	0.7	41.0	91
15	1.2	0.0	1.5	-0.2	-1.1	6.6	47.6	86
16	2.1	0.0	3.7	-0.1	-0.3	5.1	52.7	94
17	2.3	0.0	4.1	1.3	0.6	0.6	53.3	88
18	0.8	0.0	1.7	0.3	0.1	1.4	54.7	99
19	-2.2	0.0	0.3	-3.3	-0.3	0.5	55.2	91
20	-4.9	0.0	-3.3	-5.3	-5.4	0.0	55.2	85
21	-7.3	0.0	-4.7	-10.9	-11.7	0.0	55.2	89
22	-1.0	0.0	-6.1	-12.2	-13.1	0.7	55.9	87
23	-6.9	0.0	-0.5	-9.8	-1.2	2.8	58.7	96
24	-2.5	0.0	-0.7	-5.3	-8.2	0.3	59.0	93
25	-0.1	0.0	-0.5	-1.5	-1.4	1.6	60.6	97
26	-0.5	0.0	0.4	-1.2	-1.7	0.1	60.7	90
27	-0.4	0.0	0.2	-1.1	-0.7	0.4	61.1	100
28	0.1	0.0	1.2	-1.8	-0.3	4.8	65.9	98
29	0.1	0.0	0.2	-0.7	-0.7	2.2	68.1	99
30	-0.4	0.0	0.8	-1.1	-3.9	0.1	68.2	87
31	-0.2	0.0	0.6	-3.1	-5.5	2.3	70.5	94
Month	-2.0					70.5		
Normal 1981-2010	*-5.6*					*46.0*		

February

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	-0.1	0.0	0.2	-1.6	-1.1	6.9	6.9	100
2	-1.2	0.0	-0.2	-2.1	.	5.4	12.3	100
3	-1.5	0.0	-0.4	-0.3	-3.4	1.3	13.6	99
4	-3.1	0.0	-1.6	-3.8	-6.1	0.3	13.9	97
5	-0.3	0.0	-1.7	-4.3	-4.8	1.5	15.4	92
6	-0.2	0.0	3.6	-4.2	-0.5	0.3	15.7	96
7	0.6	0.0	2.4	-2.2	-6.1	0.0	15.7	70
8	-4.3	0.0	-0.6	-7.2	-0.4	0.0	15.7	65
9	-3.1	0.0	0.7	-9.7	-12.1	0.8	16.5	100
10	3.6	0.0	7.8	0.4	-0.2	0.0	16.5	77
11	1.9	0.0	5.7	-0.2	-2.2	0.0	16.5	91
12	0.7	0.0	1.8	-0.9	-2.7	0.0	16.5	87
13	-1.2	0.0	1.5	-6.1	-10.2	1.9	18.4	98
14	-0.5	0.0	0.5	-0.1	-0.1	0.7	19.1	96
15	-9.8	0.0	-0.1	-14.7	-23.1	0.0	19.1	81
16	-7.6	0.0	-1.8	-15.7	-23.4	0.0	19.1	76
17	-2.2	0.0	-0.2	-6.3	-8.7	2.9	22.0	83
18	0.7	0.0	2.9	-1.6	-0.1	0.5	22.5	72
19	2.4	0.0	3.6	-1.4	-0.5	1.2	23.7	100
20	2.1	0.0	3.7	1.5	1.4	2.2	25.9	96
21	1.2	0.0	0.2	0.8	0.6	5.8	31.7	97
22	0.8	0.0	1.4	0.2	-0.1	2.6	34.3	87
23	1.3	0.0	2.4	0.1	-1.3	2.1	36.4	79
24	1.2	0.0	0.2	0.4	0.0	0.8	37.2	96
25	0.2	0.0	3.4	0.1	0.4	0.0	37.2	94
26	0.7	0.0	1.7	0.3	0.3	0.0	37.2	96
27	0.2	0.0	0.9	-0.3	-0.4	0.0	37.2	90
28	0.5	0.0	0.1	-0.4	-0.6	0.5	37.7	97
Month	-0.6					37.7		
Normal 1981-2010	*-6.3*					*32.0*		

WEATHER CONDITIONS IN JOKIOINEN 2015. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute*

March

	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	1.4	0.0	2.5	0.6	0.3	0.3	0.3	92
2	1.6	0.0	2.3	0.9	0.1	2.6	2.9	100
3	0.9	0.0	1.8	0.3	0.1	4.0	6.9	99
4	0.4	0.0	1.0	0.0	-0.1	4.2	11.1	99
5	0.3	0.0	2.0	-0.8	-0.8	0.2	11.3	97
6	0.9	0.0	1.5	-0.9	-2.5	5.3	16.6	99
7	1.4	0.0	3.4	-0.8	-0.7	1.2	17.8	91
8	4.9	0.0	7.7	3.0	2.1	0.9	18.7	92
9	4.9	0.0	9.0	2.1	3.2	0.0	18.7	66
10	3.2	0.0	4.9	-0.3	-5.5	0.0	18.7	87
11	2.7	0.0	6.4	1.2	0.2	0.0	18.7	67
12	-0.5	0.0	6.8	-6.5	-11.1	0.0	18.7	79
13	-0.5	0.0	7.0	-7.8	-12.4	0.0	18.7	49
14	-0.2	0.0	7.9	-7.3	-11.7	0.0	18.7	59
15	1.3	0.0	10.4	-6.3	-11.5	0.0	18.7	55
16	2.8	0.0	12.1	-5.0	-10.4	0.0	18.7	41
17	2.8	0.0	11.3	-5.0	-9.5	0.0	18.7	61
18	2.4	0.0	12.6	-5.7	-10.0	0.0	18.7	48
19	2.9	0.0	10.7	-4.9	-9.9	0.0	18.7	66
20	0.8	0.0	5.2	-1.0	-3.5	0.0	18.7	59
21	-3.1	0.0	0.1	-5.7	-7.3	0.0	18.7	39
22	-4.1	0.0	0.6	-11.8	-16.2	0.0	18.7	78
23	1.5	0.0	2.4	-0.8	-0.8	1.9	20.6	99
24	2.8	0.0	6.6	0.5	0.3	0.0	20.6	76
25	-2.4	0.0	0.5	-4.6	-5.8	0.0	20.6	54
26	-1.3	0.0	2.2	-5.9	-9.7	0.0	20.6	44
27	1.8	0.0	4.0	-0.6	-1.4	1.6	22.2	96
28	2.8	0.0	4.8	0.8	2.0	4.6	26.8	97
29	2.1	0.0	4.0	0.4	0.0	5.7	32.5	90
30	1.1	0.0	3.7	0.3	0.5	4.5	37.0	99
31	1.6	0.0	3.2	0.3	0.0	0.7	37.0	93
Month	1.2				-7.2	37.7		
Normal 1981-2010	*-2.4*					*32.0*		

April

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	2.1	0.0	4.4	0.1	-2.7	0.8	0.8	83
2	1.8	0.0	3.7	1.5	1.1	0.0	0.8	91
3	1.4	0.0	3.1	0.3	-0.7	0.3	1.1	78
4	1.9	0.0	4.7	0.4	-0.3	1.8	2.9	87
5	2.0	0.0	6.3	-0.5	-3.2	0.0	2.9	84
6	2.3	0.0	7.5	-3.8	-8.3	0.0	2.9	66
7	4.4	0.0	9.8	1.2	0.6	0.7	3.6	87
8	5.2	0.0	8.0	3.1	0.8	0.0	3.6	47
9	6.7	0.0	12.0	2.1	-0.2	0.0	3.6	39
10	6.5	0.0	11.0	0.4	-2.2	0.0	3.6	47
11	7.9	0.0	14.6	0.6	-4.1	0.0	3.6	41
12	6.3	0.0	14.9	3.4	-0.8	1.7	5.3	93
13	4.5	0.0	10.3	1.1	-0.1	1.0	6.3	52
14	1.2	0.0	3.3	-0.1	-0.2	1.1	7.4	83
15	2.0	0.0	6.8	-2.1	-6.0	0.7	8.1	60
16	2.3	0.0	6.3	-2.0	-6.4	2.4	10.5	80
17	3.3	0.0	7.4	0.5	-0.1	0.2	10.7	72
18	2.3	0.0	5.8	-1.5	-3.6	0.0	10.7	61
19	5.8	0.8	10.4	-1.4	-4.5	0.0	10.7	63
20	6.8	2.6	11.9	1.6	-0.2	0.0	10.7	38
21	7.6	5.2	12.7	0.9	-4.1	0.0	10.7	41
22	4.9	5.2	9.9	-0.5	-4.6	1.0	11.7	53
23	5.7	5.9	9.1	3.8	1.9	0.0	11.7	46
24	3.2	5.9	7.1	-1.0	-4.5	0.0	11.7	51
25	5.8	6.7	12.5	-3.8	-9.6	2.4	14.1	29
26	6.3	8.0	9.8	4.2	2.9	3.2	17.3	98
27	6.7	9.7	10.7	2.2	2.6	6.0	23.3	65
28	8.0	12.7	13.3	5.2	5.6	0.0	23.3	48
29	4.0	12.7	6.8	3.5	2.3	19.1	42.4	93
30	5.5	13.2	10.3	1.3	0.8	0.0	42.4	68
Month	4.5					42.4		
Normal 1981-2010	*3.5*	*26.4*				*30.0*		

WEATHER CONDITIONS IN JOKIOINEN 2015. DATA FROM THE OBSERVATORY OF JOKIOINEN

(location 60.81402°N, 23.49829°E according to map datum WGS 84**, altitude 104 m).** *Data source: Finnish Meteorological Institute*

May

	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	9.0	17.2	14.4	3.8	2.5	0.0	0.0	43
2	7.2	19.4	10.3	4.0	0.2	0.0	0.0	73
3	5.7	20.1	10.8	0.4	-3.9	1.0	1.0	65
4	6.0	21.1	12.4	-3.6	-8.8	0.0	1.0	33
5	8.9	25.0	12.4	4.3	2.0	0.0	1.0	58
6	9.5	29.5	12.9	5.7	4.1	7.5	8.5	97
7	10.9	35.4	16.3	5.2	3.9	1.6	10.1	59
8	7.4	37.8	12.8	5.5	1.2	0.1	10.2	62
9	6.2	39.0	10.8	3.5	0.7	0.0	10.2	64
10	7.6	41.6	13.1	-1.1	-6.3	2.1	12.3	37
11	8.0	44.6	13.6	5.2	5.3	2.1	14.4	63
12	8.2	47.8	10.1	6.5	5.3	16.5	30.9	89
13	7.1	49.9	7.8	7.4	7.3	6.4	37.3	95
14	7.6	52.5	12.4	5.1	4.7	0.1	37.4	65
15	4.8	52.5	9.4	0.8	-2.5	3.3	40.7	75
16	6.7	54.2	12.2	0.9	-3.6	0.0	40.7	60
17	8.3	57.5	12.3	1.1	-3.1	0.1	40.8	57
18	7.6	60.1	12.3	2.5	-1.6	0.0	40.8	64
19	10.5	65.6	16.2	5.1	1.5	0.7	41.5	48
20	10.5	71.1	15.4	6.5	5.9	0.0	41.5	53
21	10.4	76.5	15.0	7.0	4.1	0.6	42.1	58
22	10.7	82.2	16.9	3.0	-1.7	1.8	43.9	44
23	9.4	86.6	12.9	7.9	6.7	0.0	43.9	52
24	9.0	90.6	14.3	3.9	0.9	0.0	43.9	35
25	11.1	96.7	16.7	3.0	-0.7	0.0	43.9	51
26	11.7	103.4	16.8	3.6	-1.7	1.8	45.7	50
27	11.6	110.0	16.7	7.7	6.3	0.0	45.7	55
28	11.8	116.8	17.6	4.3	-0.2	0.0	45.7	44
29	9.5	121.3	13.5	6.6	3.8	3.6	49.3	89
30	12.1	128.4	16.8	5.4	1.2	0.1	49.4	35
31	10.9	134.3	14.3	8.8	8.5	0.0	49.4	42
Month	8.9					49.4		
Normal 1981-2010	*9.8*	*163.6*				*41.0*		

June

Date	Temperature					Precipitation		Relative humidity
	Mean	Effective temp. sum	Max	Min	Surface Min		Sum	(mean)
	° C	° C	° C	° C	° C	mm	mm	%
1	10.8	140.1	14.7	7.7	6.4	1.8	1.8	79
2	12.0	147.1	16.8	6.8	4.6	3.3	5.1	37
3	10.9	153.0	13.7	9.4	8.8	5.6	10.7	73
4	10.8	158.8	14.4	7.1	5.5	0.0	10.7	54
5	11.5	165.3	16.7	5.5	1.7	0.0	10.7	36
6	12.6	172.9	17.8	2.3	-1.8	0.4	11.1	66
7	11.9	179.8	15.4	9.8	8.4	2.2	13.3	56
8	11.2	186.0	16.3	6.6	2.5	0.0	13.3	44
9	11.0	192.0	16.6	4.1	-0.8	0.0	13.3	37
10	12.2	199.2	17.3	4.5	0.4	0.0	13.3	34
11	11.8	206.0	14.4	8.8	6.8	0.4	13.7	37
12	14.6	215.6	22.4	8.5	7.4	0.2	13.9	47
13	15.8	226.4	22.5	7.9	3.1	1.5	15.4	35
14	11.8	233.2	13.3	9.8	8.3	1.6	17.0	96
15	10.1	238.3	13.4	8.7	8.7	0.9	17.9	52
16	9.6	242.9	12.9	6.0	3.3	0.0	17.9	51
17	11.4	249.3	16.1	4.8	2.5	0.6	18.5	36
18	10.2	254.5	11.7	8.6	6.7	13.8	32.3	95
19	12.8	262.3	16.2	10.6	10.0	0.0	32.3	75
20	11.9	269.2	17.1	4.9	2.0	13.6	45.9	85
21	13.2	277.4	17.6	8.1	4.4	0.3	46.2	66
22	12.4	284.8	16.6	8.6	5.7	0.4	46.6	87
23	14.3	294.1	20.0	7.0	4.9	10.9	57.5	53
24	13.7	302.8	17.0	12.8	11.9	8.0	65.5	83
25	12.7	310.5	15.6	11.9	11.5	0.0	65.5	77
26	12.2	317.7	16.2	6.0	2.1	11.8	77.3	82
27	12.4	325.1	16.5	9.5	9.5	0.5	77.8	78
28	15.6	335.7	20.8	11.0	10.5	0.0	77.8	46
29	16.8	347.5	22.3	10.7	10.1	1.0	78.8	35
30	14.6	357.1	19.5	12.6	11.8	8.8	87.6	73
Month	12.4					87.6		
Normal 1981-2010	*14.0*	*437.9*				*63.0*		

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