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Higher Crop Yield Levels in the North Savo Region—Means and Challenges Indicated by Farmers and Their Close Stakeholders

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Abstract: The sustainable intensification of farming systems is expected to increase food supply and reduce the negative environmental effects of agriculture. It is also seen as an effective adaptation and mitigation strategy in response to climate change. Our aim is to determine farmers' and other stakeholders' views on how higher crop yields can be achieved from their currently low levels. This was investigated in two stakeholder workshops arranged in North Savo, Finland, in 2014 and 2016. The workshop participants, who were organized in discussion groups, considered some agricultural policies to discourage the improvement of crop yields. Policy schemes were seen to support extensification and reduce the motivation for yield improvements. However, the most important means for higher crop yields indicated by workshop participants were improved soil conditions with drainage and liming, in addition to improved crop rotations, better sowing techniques, careful selection of cultivars and forage grass mixtures. Suggested solutions for improving both crop yields and farm income also included optimized use of inputs, focusing production at the most productive fields and actively developed farming skills and knowledge sharing. These latter aspects were more pronounced in 2016, suggesting that farmers' skills are increasingly being perceived as important.

Keywords: Northern Europe; forage grasslands; spring cereals; drainage; soil conditions; farm management; agricultural policy

1. Introduction

Agriculture in northern European regions, such as Finland, is limited by the short growing seasons and low accumulated temperature sums during the growing period [1]. Climate change is projected to prolong the growing seasons and increase the temperature sums [2,3]. Crop yields are projected to increase in Northern Europe [1,4], although the range in climate change projections allow for both positive and negative yield effects [5]. The potential for higher crop yields has been identified in new, better adapted cereal cultivars for longer growing periods and higher temperature sums [5,6]. Yields of forage crops, such as timothy, may also increase [7]. However, there are significant challenges to be solved before yield gains may be actualized. Pest and disease pressure is also likely to increase with the higher temperature sums and warmer winter conditions [8]. The increased frequency of extreme weather conditions, such as increased precipitation, heavy rainfall and drought, further

challenge field drainage and water retention [9]. More frequent drought and heat stress with other environment-related constraints may lead to higher yield variability in different regions [5,8,10].

The North Savo region, located in the middle-eastern part of Finland, is specialized in dairy milk and beef production. Seventy percent of farm income in the North Savo region comes from milk [11]. Almost 60% of the cultivated area is covered by grass in the region and approximately 70% of the land area of dairy and beef farms is covered by grass [12]. Cereals are often cultivated in rotation with forage grasses that are usually kept in production for 3–4 years and used for silage production [13]. Grass is renewed so that a grass–cereal seed mix is sown in spring. Then, spring cereals are harvested in August–September and grass is grown for the next 3–4 years, with 2–3 cuts per year. After 3–4 years, the feed quality of grass deteriorates due to weeds. The grass forage species cultivated are mainly timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratensis* Huds.). These are preferred because of their combination of high winter tolerance, reasonably high yield capacity and high nutritive value under Finnish conditions and management practices [14] (Virkajärvi et al. 2015). The most important forage legume is red clover (*Trifolium pratense*). Timothy–red clover mixes are used as well [15]. The level of nitrogen fertilization per hectare of timothy or timothy–meadow fescue swards is relatively high (180–200 kg N/ha), but it is significantly lower (50–100 kg N/ha) in the case of timothy–clover forages [15].

Sufficient quality and quantity of yields of grass silage and cereals are important for the economic viability of agriculture in the region. The average milk yield per cow is above 8000 kg per cow per year [12]. This is achieved by using good quality grass silage and the use of concentrates and protein feeds, as well as long-term cow-breeding efforts. On average, 46% of the energy content of dairy cow feed is from concentrates, and 54% is from forage feeds [14]. However, there is some variation in milk yields among farms for various reasons. Typically, large dairy farms, which have recently invested in larger cattle houses, have high capital costs and produce higher milk yields with a higher turnover per animal. This is to achieve high gross margins, cover capital costs and thus achieve a shorter payback time of farm debts [16]. Low milk yields are considered clearly uneconomic (ibid).

Agricultural land in the region is often best suited for grassland-based forage production, and precipitation is usually sufficient for good quality grass silage yields. The annual precipitation clearly exceeds annual evaporation, except in the middle of the summer [17]. A large part of the agricultural land in the region is also suitable for cereal production, even though cereal yields are 10–20% lower than the cereal yields in the most favorable agricultural production regions in Finland [12]. The Regional Council of North Savo has stated that agricultural production should be increased from 310 million liters up to 340 million liters by 2020, and it has stated its aim that North Savo lead the area of milk economy in Finland by 2030 [18].

The Rural Development Programme (RDP) for Mainland Finland 2014–2020 indicates, based on earlier studies, that investment support has been highly significant for carrying out investments in Finnish agriculture [19]. The RDP promotes economically viable and environmentally sound agriculture. Both negative and positive impacts can be seen on the environment due to farming. The RDP specifies measures to combat negative impacts of agriculture on ecosystems, which include eutrophication, acidification and clouding of water bodies, destruction of habitats, and loss of biodiversity on farmland (e.g., low species richness on intensively managed farmland compared to extensively managed farmland such as grassland meadows). The RDP for 2014–2020 in Mainland Finland includes some few measures targeted for decreasing greenhouse gas emissions from agriculture [19]. The positive environmental impacts, also considered in the RDP, include different types of semi-open habitats with a diversity of species and biotopes, open agricultural landscapes (agricultural land is only 8% of the total land area in the North Savo region), maintaining cultural environments and inviting living environments. Nutrient leaching from manure is increasingly a local problem due to the concentration of livestock farming and its separation from arable farming. More than 90% of the solid matter and nutrient loading from farming occurs outside the growing period, which is between May and early September [19].

One of the key challenges in the North Savo region is still the relatively low land productivity in terms of yields. Higher crop yields could significantly improve gross margins and the economic viability of farms in the region [20], as well as in the whole country [21]. Yield gaps, indicating the differences between potential and actual yield levels for the whole of Finland have been identified to be relatively high [6]. The North Savo region is not an exception in this respect.

Our main objective is to identify farmers' and other stakeholders' views on the challenges and opportunities concerning crop yields. Climate change and sustainable intensification have been topics of intense debate in the agricultural research and farming community for years. Are farmers aiming to achieve higher crop yields, and if so, what are the measures they consider the most important? Are farmers and their close stakeholders—those in direct contact or contractual agreement with farmers, such as input suppliers, food industry and agricultural extension—prioritizing the same challenges and opportunities as those identified by researchers? We tried to find answers to these questions by organizing large-scale workshops for local farmers and their local stakeholders in the North Savo region in November 2014 and 2016. We present the main outcomes of the workshops and compare the outcomes to the findings of researchers. We conclude by summarizing the key measures farmers see as most relevant and which have also been identified by researchers. Finally, our findings have implications for further research in climate change adaptation and sustainable intensification of agriculture in northern regions.

2. Materials and Methods

We organized two open workshops for farmers and their close stakeholders, first in November 2014 and second in November 2016, in the North Savo region in eastern Finland (Table 1). In 2014, a full-day interactive seminar was conducted in Kuopio with the theme "Adaptation to climate change in North Savo agriculture", with a high focus on crop yields and related issues. The workshops were organized with the aim of having participants express their views and experiences in a way that allowed the outcomes to be collected and analyzed (e.g., in this study). The purpose of the group discussions was to motivate participants to express their thoughts. That was considered more likely to occur in a group with other, different stakeholders, who can then benefit from hearing views and experiences of other participants. Thus, the possibility to discuss with other participants was considered a major motivation for stakeholders to participate actively in the group discussions.

Table 1. An overview of the two workshops organized in Kuopio in 2014 and Iisalmi in 2016.

Workshop Time	**November 2014**	**November 2016**
Location	Kuopio	Iisalmi
Workshop title/specific theme	Adaptation to climate change in North Savo agriculture	How to increase yields under climate change
Number of participants	33	61
Stakeholder groups attending	Farmers (18) Food industry (2) Input suppliers (2) Extension (3) Education (1) Research (7)	Farmers (22) Food industry (3) Input suppliers (9) Extension (4) Agrimedia (1) Education (7) Research (15)
Invited short presentations	Altogether, eight presentations on climate change, grass production, climate change risks for crop production, plant breeding, farm economics and soil management	Altogether, nine presentations on grass mixtures, grass over-seeding, yield gaps, means to improve yields
Group work method	"Learning café" with initial groups of 5–7 persons	Traditional group work with groups of 6–8 persons

During the groupwork, session participants gave their responses concerning different climate- and yield-related challenges at different "learning café" points. All the participants circulated through all the points. The participants were allowed to spend more or less time at each point, thus the group composition at each learning café point was allowed to vary after the first set of questions. In 2016, a full-day interactive seminar was organized in Iisalmi with the theme "How to increase yields under climate change". This time, due to the large number of participants, all groups responded to all questions as one group, i.e., the group composition did not change.

More specific key questions (Annex) posed to farmers in the 2014 and 2016 workshops can be summarized as follows: What are the obstacles for achieving higher yields? What solutions are needed on farms to achieve higher yields? What would you recommend for farmers who aim for higher crop yields? Furthermore, since improved crop yields often require additional efforts, we also asked: How can both the crop yield and farm economy be maintained at a good level? What benefits do you see in improved crop yields? Have you found higher crop yields to be profitable?

Farmers and their close stakeholders were not asked to express the scale of possible crop yield increase they find attainable. Rather, it was considered more relevant to focus on the means for reaching higher crop yields, and possible benefits and profitability of attaining higher crop yields.

Group and wrap-up discussions in both workshops were documented by workshop organizers for the qualitative analysis of the discussions. The responses and statements reported by groups and their secretaries were organized under more general themes, and those themes were ranked on the basis of how many times they were raised.

3. Results

3.1. Obstacles to Higher Yields

In the November 2014 workshop, the main obstacles to achieving higher yields, according to the responses of workshop participants, were related to agricultural and agri-environmental policies that did not provide incentives for higher yields (Table 2). First, farm subsidies based on utilized agricultural area and decoupled from crop choices and production intensity are paid as specified in CAP (Common Agricultural Policy of the EU). These, as well as LFA (Less Favored Area) payments, are paid irrespective of the crop choice in the whole country. Such farm payments largely decoupled from production, however, provide incentives for keeping all available farmland in agricultural use. Decoupled payments incentivizing utilization of all available farmland areas already provide some incentives to reduce the use of production inputs and crop yields. An agri-environmental scheme implemented in Finland that includes risk-free payments which are conditional on nutrient use limitations was considered the most important policy element discouraging farmers from achieving higher crop yields and was also thought to incentivize extensive production. Grass production, in particular, was seen as being clearly more extensive because of the policy incentives.

However, the extensive use of farmland is also related to crop yield risk management: farmers allocate more land for grass silage and other grass necessary, in years of average crop yields, to safeguard sufficient roughage for dairy and other cattle, even in years of low yields (e.g., due to drought). The combination of policy incentives to keep the maximum available area under agricultural use and risk aversion thus leads to low levels of fertilization and low forage yields on grasslands. This was also found in a study by [22]. Low grassland yields, in turn, imply high costs per ton of grass roughage harvested, including logistics costs. The time window for harvesting good quality grass silage is short in northern latitudes, and only lasts for few days [14]. This leads to costs related to the immediacy of the timetable required for harvesting (timeliness costs). The situation is connected to the scattered location of field parcels and long distances to some field plots from the farms, and it implies significantly higher production costs of grass silage than would be possible from high-yield field parcels situated close to the farm center. In short, low yields, short time windows for harvesting good quality crop, and large harvested areas lead to high costs.

Table 2. Responses of farmers and close stakeholders to the question "What are the obstacles to achieving higher yields?" in the November 2014 and November 2016 workshops. The responses listed first were most frequently mentioned.

November 2014 Workshop	November 2016 Workshop
Agricultural policy	Soil quality, soil compaction
Agri-environmental policy	Attitudes: lack of interest, old habits
Both policy incentives and crop yield risk (due to drought) management lead to extensive grasslands	Policy promotes extensive production
Uncertain land tenure and short land rent contracts	Lack of know-how, measurements, resources
	Poor economic situation and profitability
	Field parcel structure, logistic costs
	Unfavorable growing conditions (weather)
	Non-optimal forage seed mixes, sowing techniques

According to the views expressed by workshop participants, uncertain land tenure and short land rent contracts, often due to agricultural policy, lead to reduced liming and drainage investments on rented land. This, in turn, implies reduced soil fertility and crop yields.

In the 2016 workshop, on the other hand, participants emphasized obstacles related to the soil condition and soil compaction, as well as farmers' attitudes, including their possible lack of interest and old habits (Table 2). Prevailing policies, especially agri-environmental support schemes, promoting extensive production and limiting P fertilization, as well as the nitrate directive, were only third ranked as obstacles, according to the discussions. Another commonly mentioned obstacle considered was the lack of know-how. One specific aspect that arose in the discussions was the lack of resources and reliable methods available to observe grass yields. Traditionally, it has not been a common practice to measure grass silage yield for each and every field parcel because silage is used on the farm and not sold outside the farm. This was identified as a concrete deficit, as "it is difficult to improve something we do not measure".

Several responses emphasized, on the other hand, that the deteriorating economic situation after 2014, especially for dairy farms, prevents investments in necessary equipment and cultivation practices for higher yields; low-cost alternatives penalize yields. Low profitability, in turn, often leads to reduced external workers, which is followed by reduced actions taken by farms toward higher crop yields. This lack of resources for field parcel-specific management is further inhibited by enlarged farm sizes and implied weakened field parcel structures. Furthermore, increased time pressure and logistic costs inhibit monitoring and actions.

Most importantly, however, it was considered that unfavorable growing conditions during many years in the last 10 years were very significant reasons for lower crop yields than expected: drought or wet conditions lead to harvesting and quality losses, especially in grass silage production, where time windows for high-quality harvests are narrow. Any delays can lead to deterioration of the feed value, crop quality and quantity.

Non-optimal forage seed mixes and techniques in sowing and sward establishment were also considered important factors for not achieving the crop yield levels which would otherwise be possible.

Responses to the question "What are the obstacles to achieving higher yields?" are summarized in Table 2.

3.2. Solutions and Means for Higher Crop Yields

In 2016, workshop participants identified means they had either applied on their own farms or had seen used by others to improve crop yields. The most frequently mentioned means were related to making soil improvements (drainage, liming, different tillage systems), applying grass mixtures,

oversowing and crop rotation. Nearly all the participants also considered their attempts to achieve higher yields economically feasible.

The participants in both 2014 and 2016 workshops considered improved seed use, seed quality and increased seed quantity, as well as maintaining the correct sowing depth and improved mechanical or chemical weed control, as important elements in yield improvement. These traditional agro-management practices can be considered as "low-hanging fruits" that farmers should detect and exploit more actively. The importance of good drainage and water retention, based on wet growing and harvesting conditions experienced in the region, were mentioned by many participants. Some participants mentioned manure fractioning as one way to improve the use of manure nutrients (Table 3). However, manure fractioning has been rather rare in the region, but it is emerging on pig farms and on some dairy farms in other parts of the country.

Some participants found crop rotation important and considered current rotations too short and insufficient for maintaining a good soil structure. Soil compaction has been an emerging problem in the region, and this concern was expressed particularly by extension specialists. They even suggested increasing the number of cultivated species, e.g., with protein crops, to facilitate longer rotations. Some farmers did not find this a very lucrative opportunity due to varying experiences (Table 4).

Table 3. Responses of farmers and close stakeholders to the question "What would you recommend for farmers who aim to achieve higher crop yields?" in the November 2014 and November 2016 workshops. The responses listed first were most frequently mentioned.

November 2014 Workshop	November 2016 Workshop
Increase grassland (seed) density	Improved drainage: makes earlier sowing and timely harvests more likely
Increase use of weed control	Improved soil structure and fertility: liming, soil structure improvements, crop rotation
Increase the use of certified seed	Optimize forage seed mixes per field parcel
Improve soil fertility—organic matter, liming, drainage	Sufficient seed use and grass density, right deepness in sowing
Manure fractioning—use N- and P-rich fractions according to the plant needs	More diverse crop rotations, crops according to soil type
	Renew high yielding forage grasslands, do not wait for low yields
	Improve your knowledge: participate in "forage grassland groups" to share experiences
	Crop protection, harrowing grasslands in spring
	Fertilization: amount and timing per field parcel
	Increased protein crop production in the region; more rotation—oilseeds, faba beans

Table 4. Means for attaining higher crop yields expressed by farmers and close stakeholders of farmers (e.g., input suppliers, food industry, agricultural extension) and by researchers (right) in the workshops in 2014 and 2016. The responses listed first were most frequently mentioned by farmers and close stakeholders. Improved drainage was clearly the most frequently mentioned means for achieving higher yields, while there were only minor differences in how frequently other means were mentioned.

	Farmers and Close Stakeholders	Researchers
Improved drainage and water management	×	×
Quality and quantity of seed	×	×
Optimized forage seed mixes	×	×
Improved soil structure and fertility, through liming etc.	×	×
Crop protection, weed control, harrowing	×	
New cultivars, varieties	×	×
Change policy incentives	×	
Sharing knowledge and experiences	×	×
Seeding techniques	×	
Need to improve profitability, weak economic situation	×	
Crop rotations (more crops)		×
Yield measurements, monitoring	×	×

The overall means prioritized for attaining higher yields (Table 4) show a high level of consensus and agreement among the different participant groups. Farmers had experienced, and researchers had proved, the importance of the use of high-quality seeds and forage seed mixes to produce more robust and good quality forage. Drainage and liming were considered important due to adverse weather conditions and efficient nutrient use. The participants also shared positive views on the use of new cultivars. Sharing knowledge and experience was considered important. Particularly, peer groups of farmers had reported good results in the region. There were differing views, or at least differing emphasis between farmers and other participants, on the role of policy incentives, current profitability, and specific crop protection and weeding issues.

3.3. Policy Support and Resources for Yield Improvements

Farmers clearly emphasized the role of agricultural and agri-environmental policies, especially in the 2014 workshop, while others did not consider policies the root causes for low crop yields or farm profitability. While farmers argued that reduced farm incomes and profitability were clearly detrimental for efforts promoting crop yields and soil quality, other participants did not consider reduced profitability a main problem in terms of crop yields. Rather, some participants said that the increased use of inputs were a core means of improving crop yields and farm incomes. Farmers, in turn, expressed their experience that the poor economic situation on farms allowed clearly less working time, funding and other resources to be used in investing in soil conditions or as inputs promoting crop yields.

3.4. Environmental Considerations

The workshop participants in 2016 considered improved yields to concur with environmental benefits. Improved crop growth was thought to bind nutrients and reduce nutrient leaching. Furthermore, increasing yields were thought to reduce all other environmental impacts per produced product. It was also mentioned that improved crop canopies brought by intensified production improve soil quality in the long term.

3.5. Future Views

It is also interesting that no participants in the workshops mentioned the potential of fruit trees and irrigation as future opportunities. This may be explained by the fact that questions or presentations related to such opportunities were not given in the workshops. Nevertheless, it is interesting that no participants brought up such future opportunities. Significantly increasing temperature sums

could make at least apple and pear trees viable in the region, and there will not be any scarcity of surface water that could be used for irrigation. No one from the local education (agricultural college teachers) or from the local farming community (farmers, extension services, input suppliers, food industry) brought up entirely new crops or agricultural production lines as potential yield or business opportunities.

4. Discussion

4.1. Solutions and Means for Achieving Higher Crop Yields

The workshop participants identified unfavorable growing conditions related to northern conditions as important drivers for low yields. On the other hand, they can also be attributed to non-optimal management-related issues, such as soil compaction resulting from driving heavy machinery on wet soils [23] or low fertilization levels reducing yields [24]. Fertilization affects the yields remarkably in conditions such as those in Finland (and North Savo), where the production is limited by the availability of nutrients during intensive growing phases of a short growing season [25].

Similarly, short growing seasons and the occurrence of late and early frosts were seen as limiting the production opportunities in boreal regions in a survey study of agrometeorological and agronomy experts in 26 European countries [4]. Increasing climate variability [26] is also increasingly affecting crop production [9]. Improved management options that increase yields and reduce their variability are important for improving the resilience of farms to climate change [27]. The workshop participants saw soil improvements, such as drainage, liming and new tillage systems, as important means for achieving yield improvements. In a survey-based study by [4], tillage management in boreal regions was also viewed as important from the point of view of erosion management because precipitation is projected to increase in Finland [3]. Autonomous adaptation by changing the sowing times was not mentioned in either of the workshops, even though this has been observed in Finland [28].

Applying grass mixtures, oversowing and crop rotations were seen as important practices by the workshop participants. Oversowing is a practice where a farmer sows additional seeds in a grassland field over subsequent years after its establishment. Oversowing is often used by forage grass producers in the region in the hope of increased plant density of swards. This is often needed due to winter damage to grasslands. However, research to prove the benefits of oversowing on a field scale in Finland is lacking, and on a smaller research plot scale, the benefits of oversowing have been relatively marginal (recent study [29], data not published). Using grass mixtures to achieve higher yields has been shown to work in low N input systems [30,31]. However, there is no research data from the North Savo region to show how the diversification of mixtures from a common two-species mixture of timothy and meadow fescue affects yield levels in the region when normal farming practices with relatively high nitrogen input are also applied. Current evidence says that high nitrogen input is detrimental to plants such as clovers in the grass sward [32] due to the intense growth of timothy and other species, which are highly competitive at high nitrogen fertilization levels. Thus, maintaining clovers or other N-fixing species is likely to require a relatively low nitrogen input. However, the reality on the farm scale also requires spreading all stored manure from the in-house period during the growth period. This may restrict the use of low-intensity grass mixtures, at least on farms with a high animal density [15].

Crop rotations that include perennial plants, such as forage grasses, are important for increasing the yield potential via improved soil structure [33]. More diverse crop rotations were mentioned in both the 2014 and 2016 workshops as a means to avoid or to eliminate soil compaction in the region. This view is at least partly supported by recent literature. According to Peltonen-Sainio et al. (2017) [34], who interviewed 16 farmers in Finland, there was a noted desire for more diverse rotation types, originating from adverse experiences with cereal monocultures and soil degradation. The soil compaction problems in the North Savo region have been found on dairy farms as well, despite grassland–cereal rotations dominating the land use on dairy farms. In the 2014 workshop, high

axle loads were seen as an important reason behind the soil compaction problems, not only crop monocultures. This was noted also in an earlier study conducted in Finnish conditions [23].

Overall, it can be concluded that the importance of grass mixtures and oversowing to crop yields is relatively little evidenced in the peer-reviewed literature, while farmers consider them important if they aim for higher grass yields. The peer-reviewed literature largely agrees with the farmers and other workshop participants on the importance of the soil structure maintained by diverse crop rotations and avoiding high axle loads of farm machinery.

4.2. Policies Hampering Yield Improvements

The workshop participants indicated that agricultural and agri-environmental policies provide incentives which are not compatible with higher yields. Risk-free payments, which are conditional on limitations on N and P fertilization, as well as premium payments for high nature value set-aside areas, are seen as effective measures for keeping fertilization levels somewhat lower than they would be otherwise (i.e., if based on market prices of crops and fertilizers). These statements are somewhat supported by results of recent agricultural economics research. On the farm level, it is consistent with microeconomic theory to assume that risk-averse farmers are tempted to take risk-free payments which are conditional on nutrient use limitations, as long as these do not reduce fertilization and crop yield levels very significantly. This has been recently shown in a microeconomics-based study, which included a model parameterized for Finland [22]: a market solution, with no currently existing agri-environmental payments or nutrient limitations, would imply higher fertilization levels. However, crop yields of cereals under the 'market solution', i.e., with no agri-environmental payments, would be only a little higher than the average cereals yields observed during the last 20 years, when agri-environmental payments have been in place. Thus, in the case of cereals, the agri-environmental scheme may not to be the primary reason for low crop yields.

Some more yield effects, at the farm level, could be realized through a more dynamic agri-environmental scheme. For example, the reduced yields and higher share of land allocated to set-aside areas may reduce the use of other inputs, such as liming and crop protection. Furthermore, the risk-free payments and premium payments for set-aside areas would offer the same or a better income (depending on crop prices) even with reduced inputs. Reduced liming would limit soil pH gradually and thus also crop yield levels [22]. A recent microeconomic dynamic optimization-based analysis [20] also shows the dependency of crop yields and use of liming and fungicides (affecting crop yields) in the North Savo region over a 30-year time period. Low crop prices demotivate farmers to use inputs and this affects crop yields, if not much in the short run, significantly in the longer run. Thus, it can be concluded that the concerns of the workshop participants about the disincentive effects of CAP decoupled payments and agri-environmental payments are consistent with microeconomic theory and some recent research results.

Nevertheless, it is difficult to estimate whether the agricultural and agri-environmental policy schemes are the primary reasons for low crop yields, or for relatively large yield gaps in Finland [6]. The farm-level effects of these policies also depend significantly on both the biophysical and socioeconomic farm characteristics [22].

Assessment of economic and environmental effects of agri-environmental policy scheme in Finland 2007–2013 [35] found a decreased production intensity due to the agri-environmental policy. It was found that the policy scheme most likely had positive environmental effects (e.g., reduced fertilization), implying that, without the agri-environmental scheme, there are higher nutrient balances and nutrient leaching into watercourses in intensive production areas. In fact, the agri-environmental scheme in 2007–2013 was designed to prevent local hotspots of nutrient surpluses and nutrient leaching through the fertilization limits imposed and risk-free support payments in compensation for the cost of implementing the FAEP measures. Hence, the agri-environmental policy scheme incentivizes extensive production. However, it was also found that the cereal production area would be 15% smaller without the agri-environmental scheme [35]. This means that the risk-free payments incentivize lower levels of

fertilization and slightly lower crop yields of cereals cultivated on larger areas. This finding confirms the land use effect of the agri-environmental scheme, which was suspected by farmers in the 2014 workshop, especially. Comments given in the 2014 workshop indicated farmers' observations that some farmers do not care much about the level of crop yields but cultivate extensively because of risk-free farm subsidies, instead of using more inputs which may or may not pay off in terms of crop yields and economic returns due to uncertain weather conditions and market prices.

The workshop participants also indicated, especially in the 2014 workshop, that grasslands, not only cereals, are clearly more extensively cultivated because of policy incentives than they would be otherwise. This was considered to be caused by farm subsidies decoupled from production, though with an obligation that all farmland must be kept in good agricultural condition. In fact, grasslands can be low-cost options for keeping land in good agricultural condition.

Some workshop participants stated that both policy incentives and crop yield risk management jointly lead to extensive forage production, low yields and high costs per ton of crop harvest. In other words, agricultural and agri-environmental policies promote extensive forage production, which also serves as a yield risk management strategy. Allocating more land for silage grass than needed (in years of average grass yields) is one way to hedge against low grass yields (e.g., due to drought risk). This practice of keeping the grassland area larger than needed in average years is a typical crop risk management strategy on dairy farms, in addition to keeping some buffer stocks of silage [36]. However, reaching higher average grass forage yields could also reduce risks [36]: 15% higher crop yields (under A1B climate in the mid-21st century) would reduce the risk of insufficient silage considerably if the land use remained unchanged. With 15% higher grass yields, a farmer may reduce the land area allocated for silage grass significantly without increasing the risk of insufficient silage for cattle feed. Hence, higher crop yields would cut overall farm costs. However, responses from the 2014 workshop suggest that the decoupled farm subsidies and the agri-environmental policies provide incentives for staying within the nutrient use limits and allocating more land for grass silage. This result was also confirmed by [35], since it reported 14% lower grassland areas in the counterfactual scenario, with no agri-environmental scheme, than in the baseline for the whole country.

Another risk management measure, discussed mainly in the 2014 workshop, was to re-evaluate fertilization needs during the growing season. If the first silage grass cut in June is of good quality and quantity, then a farmer may reduce fertilization of the second and possible third cuts, since he or she is already very likely to have sufficient grass silage needed for feeding the cattle during the in-house period. Nevertheless, having an alternative feasible way to use excess silage, e.g., for biogas production, would also make achieving high yield levels a reasonable goal. When farmers do not have a use for the excess grass silage, they would nevertheless accept lower grass forage yields than attainable yields, at least during years when average yields can be easily attained. Hence, the views expressed in the 2014 workshop are logical: policy conditions which incentivize keeping a maximal farmland area available in active production promote farming practices that do not aim for high crop yields.

Overall, the views of farmers and their close stakeholders concerning extensive land use and lower crop yields due to agricultural and agri-environmental policies are largely compatible with the recent agricultural economics research. However, some farmers' views, especially in the workshop held in November 2014, considered policies the main obstacles to higher crop yields; this may be unwarranted, since there are also several other factors affecting low crop yields, not least reduced crop prices [20], which have decreased in real terms since 2000 [12].

Policy incentives for extensive production were considered to lead to adverse yields and economic effects in the long run, since, as stated by farmers, large harvested grassland areas often located far from the farm center lead to high costs linked to short timeframes for harvesting and other aspects. Production costs of grass silage are, however, likely to be lowest when harvesting high grass yields close to the farm [36].

4.3. Higher Yields for Sustainable Intensification

Higher yields on managed fields could also provide environmental benefits, as they would allow producing the same amount on a smaller land area. Currently, there are more areas of farmland in the North Savo region than needed for current production. Some parts of the land are allocated to be set aside or cultivated relatively extensively. Increasing crop yields could mean a lower nutrient surplus (cereals) and reduced nutrient leaching, especially if cultivated land areas could be reduced as well. Higher crop yields could imply that some land could be used for greenhouse gas mitigation, biodiversity promotion or nutrient leaching abatement through, for example, green set-aside areas, permanent grasslands or afforestation of less productive farmland. Higher yields could thus significantly contribute to improvements in productivity and the environment while still maintaining the economic viability of agriculture. Thus, higher crop yields are expressed objectives of sustainable intensification [37].

5. Conclusions

Farmers and various agricultural stakeholders in the North Savo region of Finland participated in workshops arranged in November 2014 and November 2016. The workshops identified challenges and reasons for relatively low yields in the North Savo region. The main topics for sustainable intensification and yield improvements can be summarized according to the points that the participants agreed to the most. They noted that soil structure, fertility and drainage require investments due to increasing precipitation, which is already causing problems for some soil types (organic, clay soils) of the region. However, drought was also considered a major threat in the region due to the dominance of coarse till soils. Policies should encourage such measures and investments, while current and past policies have led to extensification and some decline in crop yield levels. There was, however, some disagreement among the workshop participants as to whether policies were the main cause of stagnant crop yields and high yield gaps. There is also insufficient research evidence in the peer-reviewed literature to confirm whether some of the means for achieving higher crop yields expressed by farmers and their close stakeholders (e.g., input suppliers and farm advisors), such as oversowing and utilizing grass mixtures, really provide higher crop yields in the North Savo region. However, research may lag in time in verifying such crop yield gains, or there may be gaps in the research on individual issues which are relevant for farmers. These workshop outcomes may be taken as new challenges for research.

The farmers' attitudes, skills and knowledge concerning crop yields and farm profitability were considered relevant causes for stagnant crop yields, and, especially in the 2016 workshop, farmers' skills were considered crucial. Farmers also expressed the importance of recognizing "low hanging fruits" for improving crop yields, using conventional but not always well-perceived means, such as weed control or increased quantity and quality of seed. In other words, based on their observations, the workshop participants considered that some farmers used suboptimal practices, and thus easy improvements could be available, at least at some farms. The researchers did not bring up such easily available improvements in basic farm operations, but they did mention others linked to new opportunities, e.g., new cultivars and forage seed mixes. The existence of some easy-to-implement improvements is certainly encouraging. Nevertheless, it was well agreed, especially in 2016, that there is a need to increase monitoring and measurement of field parcel-specific silage grass yields, and on this basis, it is important to share experiences and good practices.

The significance and role of higher yields for the farm economy, as well as the importance of using core inputs affecting yields, were clearly expressed in 2016, while policy obstacles and unfavorable crop-growing conditions were mentioned more in the 2014 workshop. Inputs and practices with good payoffs were identified, including: improved seed quality/quantity, optimized seed mixes, new cultivars, crop protection, improved drainage, liming.

The results suggest, with a higher number of concrete farm-level actions recommended in 2016 compared to 2014, that proper agronomic practices affecting yields are becoming wider spread in the

region. Policy is still seen as a major obstacle for higher crop yields, but it seems that farmers' own actions, skills and knowledge are increasingly considered as driving forces needed for improved crop yields. Nevertheless, based on our evidence of recent agricultural economics literature, farmers are right in saying that policy incentives matter, and they may distort proper incentives for productivity and yield increases. Thus, policy schemes may have significant undesired effects in the long run. Detrimental policy incentives and mechanisms should be identified in more detail and changed to policies and conditions which do not discourage long-term investments and other developments supporting crop yields and sustainable intensification, as well as adaptation to climate and market changes. There are also obvious gaps and delays in research in responding to very relevant farm-level issues. Consistently combining research and stakeholder interaction can provide important insights and solutions.

Author Contributions: All authors participated in planning the workshops and collecting the data at the workshops. All authors took part in interpreting the data. H.L. designed the main outline of this paper, presentation of the summaries of the workshop outcomes, discussing the results with respect to recent literature, and drawing the conclusions. Other authors provided important insights in many details. T.P. made important suggestions to several details in all parts and some notions to the main line of the paper. P.K. included important grassland specific details and literature. X.L. made some useful suggestions to the text.

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References

1. Peltonen-Sainio, P.; Jauhiainen, L.; Hakala, K.; Ojanen, H. Climate change and prolongation of growing season: Changes in regional potential for field crop production in Finland. *Agric. Food Sci.* **2009**, *18*, 171–190. [CrossRef]
2. Ruosteenoja, K.; Räisänen, J.; Pirinen, P. Projected changes in thermal seasons and the growing season in Finland. *Int. J. Climatol.* **2011**, *31*, 1473–1487. [CrossRef]
3. Ruosteenoja, K.; Räisänen, J.; Venäläinen, A.; Kämäräinen, M. Projections for the duration and degree days of the thermal growing season in Europe derived from CMIP5 model output. *Int. J. Climatol.* **2016**, *36*, 3039–3055. [CrossRef]
4. Olesen, J.E.; Trnka, M.; Kersebaum, K.C.; Skjelvåg, A.O.; Seguin, B.; Peltonen-Sainio, P.; Rossi, F.; Kozyra, J.; Micale, F. Impacts and adaptation of European crop production systems to climate change. *Eur. J. Agron.* **2011**, *34*, 96–112. [CrossRef]
5. Rötter, R.P.; Höhn, J.; Trnka, M.; Fronzek, S.; Carter, T.R.; Kahiluoto, H. Modelling shifts in agroclimate and crop cultivar response under climate change. *Ecol. Evolut.* **2013**, *3*, 4197–4214. [CrossRef] [PubMed]
6. Palosuo, T.; Rötter, R.P.; Salo, T.; Peltonen-Sainio, P.; Tao, F.; Lehtonen, H. Effects of climate and historical adaptation measures on barley yield trends in Finland. *Clim. Res.* **2015**, *65*, 221–236. [CrossRef]
7. Höglind, M.; Thorsen, S.M.; Semenov, M.A. Assessing uncertainties in impact of climate change on grass production in Northern Europe using ensembles of global climate models. *Agric. For. Meteorol.* **2013**, *170*, 103–113. [CrossRef]

8. Hakala, K.; Hannukkala, A.; Huusela-Veistola, E.; Jalli, M.; Peltonen-Sainio, P. Pests and diseases in a changing climate a major challenge for Finnish crop production. *Agric. Food Sci.* **2011**, *20*, 3–14. [CrossRef]
9. Trnka, M.; Rötter, R.P.; Ruiz-Ramos, M.; Kersebaum, K.C.; Olesen, J.E.; Semenov, M.A. Adverse weather conditions for European wheat production will become more frequent with climate change. *Nat. Clim. Chang.* **2014**, *4*, 637–643. [CrossRef]
10. Tao, F.; Rötter, R.P.; Palosuo, T.; Höhn, J.; Peltonen-Sainio, P.; Rajala, A.; Salo, T. Assessing climate impacts on wheat yield and water use in Finland using a super-ensemble-based probabilistic approach. *Clim. Res.* **2015**, *65*, 23–37. [CrossRef]
11. Luke. Economydoctor (Farm Accountancy Data Portal). 2018. Available online: https://portal.mtt.fi/portal/page/portal/economydoctor (accessed on 25 June 2018).
12. Official Statistics of Finland (OSF). *Crop Production Statistics, Utilized Agricultural Area [Web Publication]*; Natural Resources Institute Finland: Helsinki, Finland, 2018. Available online: http://stat.luke.fi/en/crop-production-statistics (accessed on 9 April 2018).
13. Kipling, R.P.; Virkajärvi, P.; Breitsameter, L.; Curnel, Y.; De Swaef, T.; Gustavsson, A.-M.; Hennart, S.; Höglind, M.; Järvenranta, K.; Minet, J.; et al. Key challenges and priorities for modelling European grasslands under climate change. *Sci. Total Environ.* **2016**, *566–567*, 851–864. [CrossRef] [PubMed]
14. Virkajärvi, P.; Rinne, M.; Mononen, J.; Niskanen, O.; Järvenranta, K.; Sairanen, A. High output dairy farming systems in Finland. In Proceedings of the 18th EGF-Symposium "Grassland and Forages in High Output Dairy Farming Systems", Wageningen, The Netherlands, 15–17 June 2015.
15. Lehtonen, H.; Niskanen, O. Promoting clover-grass: Implications for agricultural land use in Finland. *Land Use Policy* **2016**, *59*, 310–319. [CrossRef]
16. Niskanen, O.; Heikkilä, A.-M. The impact of parcel structure on the efficiency of Finnish dairy farms. *Agric. Res. Econ. Rev.* **2015**, *44*, 65–77. [CrossRef]
17. Environment. Hydrological Observations 2018, Joint Website of Finland's Environmental Administration. 2018. Available online: http://www.environment.fi/en-US/Maps_and_statistics/Hydrological_observations/Hydrological_observations(16975) (accessed on 21 May 2018).
18. Pohjois-Savon Liitto 2014. Maakuntasuunnitelma Vuoteen 2030. Maakuntaohjelma Vuosille 2014–2017. Pohjois-Savon Liiton Julkaisu A:79. p. 60, ISBN 978-952-5759-82-2, ISBN (pdf) 978-952-5759-83-9. Available online: https://www.pohjois-savo.fi/media/liitetiedostot/maakunnan-menestyksen-avaimet/ps_mksuunnitelma2030_ja_mkohjelma2017.pdf (accessed on 21 May 2018).
19. Ministry of Agriculture and Forestry. Rural Development Programme for Mainland Finland 2014–2020. Unofficial Translation. 2014. Available online: https://www.maaseutu.fi/globalassets/rural_fi/rural-program/rural_development_programme_2014-2020.pdf (accessed on 21 May 2018).
20. Purola, T.; Lehtonen, H.; Liu, X.; Tao, F.; Palosuo, T. Production of cereals in northern marginal areas: An integrated assessment of climate change impacts at the farm level. *Agric. Syst.* **2018**, *162*, 191–204. [CrossRef]
21. Lehtonen, H. Evaluating adaptation and the production development of Finnish agriculture in climate and global change. *Agric. Food Sci.* **2015**, *24*, 219–234.
22. Lankoski, J.; Lehtonen, H.; Myyrä, S.; Ollikainen, M. Synergies and trade-offs between agricultural productivity, climate change and water quality objectives—A theoretical model and application. Presented at the XV Congress of European Agricultural Economists, Parma, Italy, 28 August–1 September 2017.
23. Alakukku, L.; Weisskopf, P.; Chamen, W.C.T.; Tijink, F.G.J.; van der Linden, J.P.; Pires, S.; Sommer, C.; Spoor, G. Prevention strategies for field traffic induced subsoil compaction: A review: Part 1. Machine/soil interactions. *Soil Tillage Res.* **2005**, *73*, 145–160. [CrossRef]
24. Mueller, N.A.; Gerber, J.S.; Johnston, M.; Ray, D.K.; Ramankutty, N.; Foley, J.A. 2012 Closing yield gaps through nutrient and water management. *Nature* **2012**, *490*, 254–257. [CrossRef] [PubMed]
25. Peltonen-Sainio, P.; Jauhiainen, L.; Palosuo, T.; Hakala, K.; Ruosteenoja, K. Rainfed crop production challenges under European high-latitude conditions. *Reg. Environ. Chang.* **2016**, *16*, 1521–1533. [CrossRef]
26. IPCC. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*; A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change; Field, C.B., Barros, V., Stocker, T.F., Dahe, Q., Dokken, D.J., Ebi, K.L., Mastrabdrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., et al., Eds.; Cambridge University Press: Cambridge, NY, USA, 2012. Available online: https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf (accessed on 21 May 2018).

27. Reidsma, P.; Ewert, F.; Lansink, A.O.; Leemans, R. Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses. *Eur. J. Agron.* **2010**, *32*, 91–102. [CrossRef]
28. Kaukoranta, T.; Hakala, K. Impact of spring warming on sowing times of cereal, potato and sugar beet in Finland. *Agric. Food Sci.* **2008**, *17*, 165–176. [CrossRef]
29. Hyrkäs, M.; Kykkänen, S.; Virkajärvi, P.; Kanninen, J.; Laakso, J.; Korhonen, P. Nurmen täydennyskylvön vaikutus satoon aukkoisessa kasvustossa. Poster presentation. In Proceedings of the Maataloustieteen Päivät 2018, Helsinki, Finland, 10–11 January 2018; Puhakainen, T., Hakojärvi, M., Eds.; Scientific Agricultural Society of Finland: Helsinki, Finland, 2018. Available online: http://jukuri.luke.fi/handle/10024/541762 (accessed on 14 June 2018).
30. Ergon, Å.; Kirwan, L.; Bleken, M.A.; Skjelvåg, A.O.; Collins, R.P.; Rognli, O.A. Species interactions in a grassland mixture under low nitrogen fertilization and two cutting frequencies: 1. dry-matter yield and dynamics of species composition. *Grass Forage Sci.* **2015**, 1–16. [CrossRef]
31. Ergon, Å.; Volaire, F.; Korhonen, P.; Virkajärvi, P.; Seddaiu, G.; Jørgensen, M.; Bellocchi, G.; Østrem, L.; Reheul, D.; Baert, J. Climate challenges and opportunities in northern and southern Europe—Role of management and exploitation of plant traits in the adaptation of grasslands. *Grassl. Sci. Europe* **2016**, *21*, 746–758.
32. Nykänen, A. Nitrogen Dynamics of Organic Farming in a Crop Rotation Based on Red Clover (*Trifolium pratense*) Ley. Ph.D. Thesis, University of Helsinki, Helsinki, Finland, 25 April 2008. Available online: http://www.mtt.fi/met/pdf/met121.pdf (accessed on 9 April 2018).
33. Ball, B.C.; Bingham, I.; Rees, R.M.; Watson, C.A.; Litterick, A. The role of crop rotations in determining soil structure and crop growth conditions. *Can. J. Soil Sci.* **2005**, *85*, 557–577. [CrossRef]
34. Peltonen-Sainio, P.; Jauhiainen, L.; Sorvali, J. Diversity of high-latitude agricultural landscapes and crop rotations: Increased, decreased or back and forth? *Agric. Syst.* **2017**, *154*, 25–33. [CrossRef]
35. Lehtonen, H.; Rankinen, K. Impacts of agri-environmental policy on land use and nitrogen leaching in Finland. *Environ. Sci. Policy* **2015**, *50*, 130–144. [CrossRef]
36. Kässi, P.; Känkänen, H.; Niskanen, O.; Lehtonen, H.; Höglind, M. Farm level approach to manage grass yield variation under climate change in Finland and north-western Russia. *Biosyst. Eng.* **2015**, *140*, 11–22. [CrossRef]
37. Tilman, D.; Balzer, C.; Hill, J.; Befort, B.L. Global food demand and the sustainable intensification of agriculture. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 20260–20264. [CrossRef] [PubMed]