

THE ISSUE ABOUT FERTILIZER RECOMMENDATION IN APPLE ORCHARDS IN NORWAY

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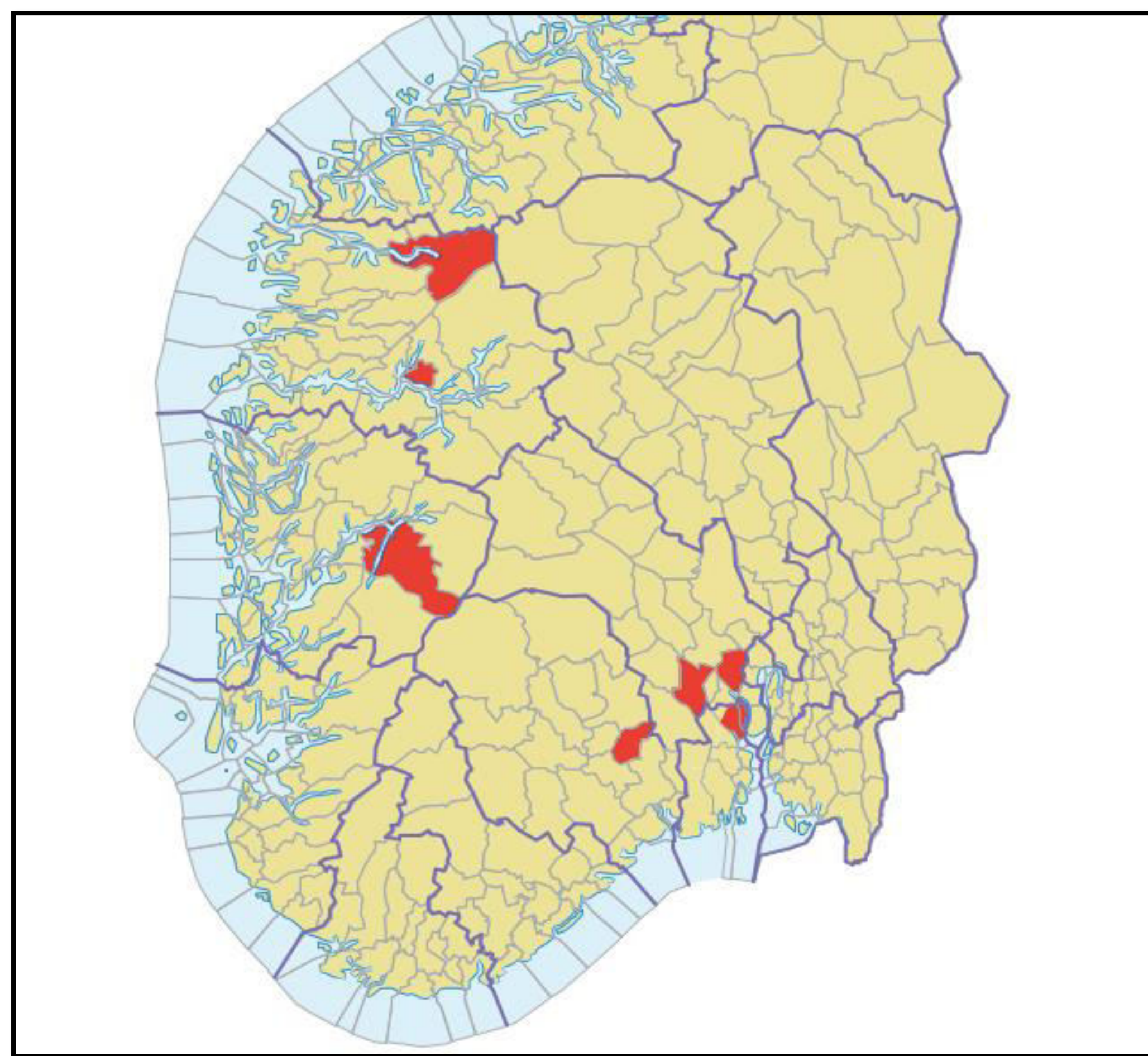
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INTRODUCTION

In the last few decades a modernization of apple production in Norway led to the planting of new high density orchards with modern international cultivars which replaced traditional ones. However, fertilization practice for apple orchard management is not standardized, meaning that farmers applied fertilizer according to their own assumption. In the meantime, some coordination between farmers and scientifically controlled fertilizer input existed by using fertilizer recommending by Norwegian Institute of Bioeconomy Research (NIBIO) and Norwegian University of Life Science (NMBU), while Norwegian Agricultural Extension Service (NLR) also took part in farmer advising. At the same time, another commercial assistance to farmers existed by EUROFINS testing company which has its own soil test interpretations. Norwegian farmers also could count on the national fertilizer producer "Yara", which provided recommendations of fertilizer application to various crops including apples ("Yara apple program").



Red areas - apple growing regions in Norway

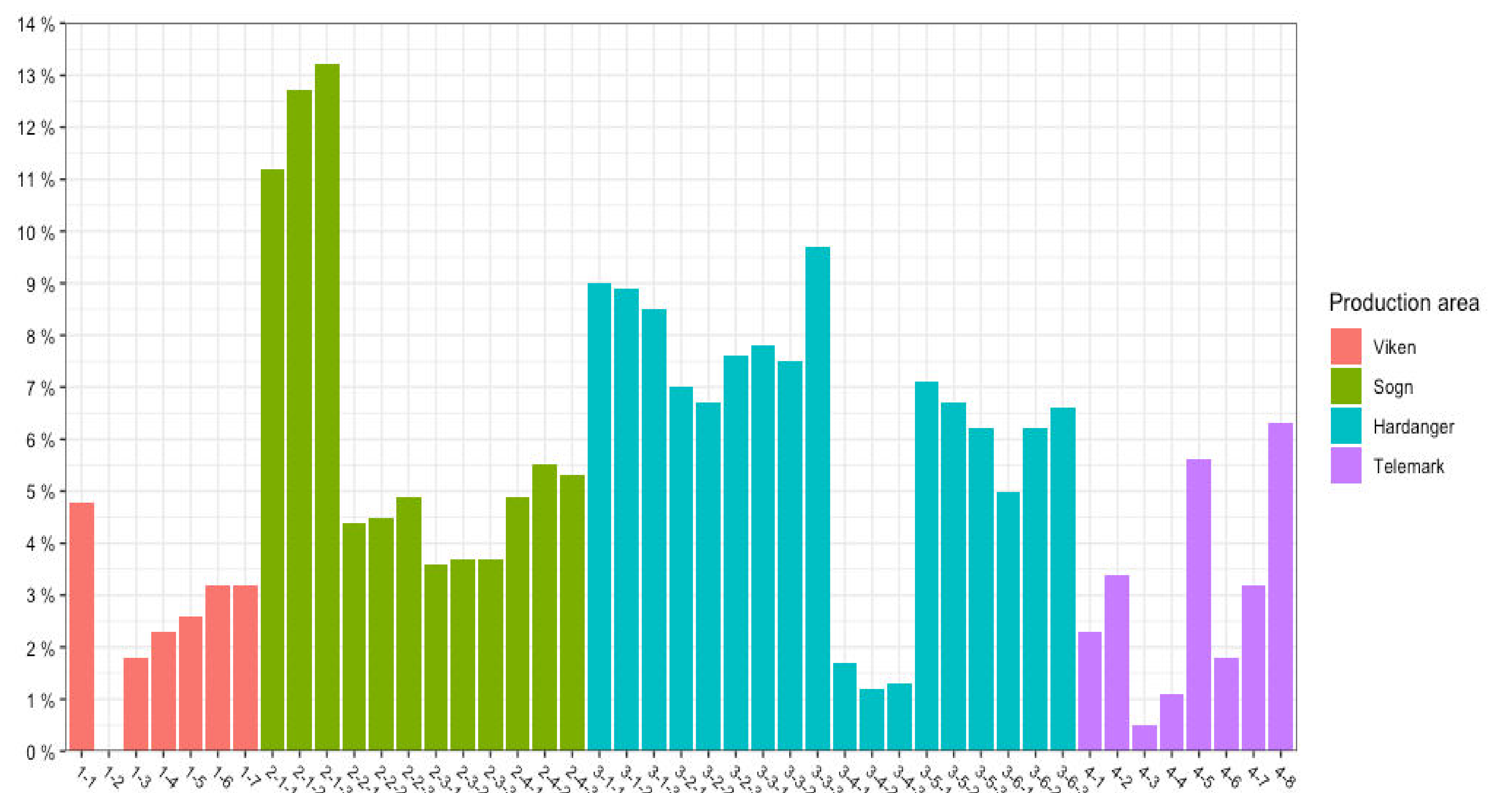
RESULTS

Now it has been reported that over 200 apple cultivars have been grown in Norway, while dominant growing varieties are a mixture of domestic and imported varieties. This varieties are: 'Geneva Early', 'Vista Bella', 'Julyred', 'Caroll', 'Raud Prins/Kronprins', 'Discovery', 'Katja', 'Sunrise', 'Summerred', 'Gravenstein', 'Raud Gravenstein', 'Åkerø', 'Delcorf', 'Aroma', 'Raud Aroma', 'Lobo', 'Roud Ingrid Marie/Karin Schneider', 'Elstar', 'Rubinstep', 'Andre Sorter', but the most relevant for production are 'Discovery', 'Summerred', 'Gravenstein', 'Aroma' and their red variants. These are grouped based upon fruit maturation and harvesting time. However, they also differ in other morphological and quality traits, e.g. time of flowering, amount and distribution of flowers, fruit taste and fruit appearance. Also, it has been used different type of rootstocks.

Table 1- The classes of macro elements in Norwegian agricultural soil analyses

Content	Low	Medium	High	Very high
P AL (mg/100g)	0 - 4	5 - 7	8 - 14	>14
K AL (mg/100g)	0-6	7 - 15	16 - 30	>30
K _{HNO3} (mg/100g)	< 30	30-79	80 - 119	>120
Mg AL (mg/100g)	0 - 6	3 - 5	6 - 9	6 - 9
Ca ALn (mg/100g)	<50	50 - 99	100 - 199	> 200

In most Norwegian apple orchards, the amount of added nitrogen through the season is about 40-75 kg/ha, maximum 90 kg/ha, while the average amount of phosphorous varied round 10-20 kg/ha, and potassium input is between 35-75 kg/ha. The main reason for such limited nutrient supply is a richness of orchard soils with organic matter (5-8%) which under the Mesic climatic conditions create the availability of nitrogen. In the past EUROFINS and NMBU/NIBIO soil analysis reports was calculated N as a "total N" without precise interpretation guide, and without the quantity of available forms of nitrogen (NH₄⁺ and NO₃⁻) in the soil. Only the recommendation of "Yara" company gave an exact content of N that apple tree needs.



Graph.1- Organic matter content in apple orchard samples in four growing regions: Viken, Sagn, Hardangen, Telemark. Third number in the code is for subsamples (1-3) (NIBIO report-2019)

Table 2- General properties of apple fruits of three varieties ('Red Aroma Ore lind', 'Discovery', 'Summerred') grown in Norway orchard (Ullensvang)

	Diameter	Length	Weight	Back ground color	Surface color	DA-meter	Soluble solids content	Titrateable acidity	Vitamin C
	mm	mm	g	L*a*b	L*a*b	I _{AD}	%	mg/l	mg %
Red Aroma Ore lind	69.8	64.4	137.7	5.1	6.65	0.965	12.5	5.83	21.1
Discovery	73.9	61.4	150.0	5.15	6.55	0.426	13.0	6.10	22.6
Summerred	71.6	60.8	141.9	5.7	5.75	0.311	12.8	5.76	20.8

By the size and the physical appearance, the apples from these growing regions are pretty similar with other countries' producers and it could be the reason why the minimum of obtained yield (>10%) yield is send to the industry. Obtained apple length, diameter, weight, with adequate coloration, which is comparable with fruits from warmer areas, is with enough firmness and freshness, what make this product attractive and notable.

Table 3- Mineral content of the peel and flash of different apple cultivars grown in Norway orchards (Ullesvang)

Apple variety		As	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	N	Ni	P	Pb	S
		µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
Red Aroma Ore lind'	Peel	0.124	213.6	0.016	0.003	0.354	4.86	2.22	0.085	995.5	58.4	0.66	522.5	0.58	47.9	0.18	38.3
	Flesh	0.023	172.3	0.016	0.001	0.017	8.31	0.97	0.001	780.4	23.0	0.32	318.9	0.10	53.9	0.16	14.6
'Discovery'	Peel	0.021	200.6	0.030	0.013	0.024	7.94	3.06	nd	925.3	63.9	0.39	470.1	0.93	51.5	0.31	47.0
	Flesh	0.005	156.8	0.016	nd	0.031	4.75	1.53	0.123	938.5	33.7	0.18	317.9	0.13	72.0	0.57	26.2
Summerred	Peel	0.063	163.5	0.044	nd	0.022	2.41	2.34	0.002	980.9	26.7	0.24	453.2	0.55	55.5	0.09	18.8
	Flesh	0.041	180.3	0.019	0.005	0.069	5.19	1.04	0.031	744.3	48.1	0.390	372.1	0.73	59.7	0.18	38.8

It could be seen that all minerals presented in apple's are most abundant in fruit peel and this organ presents a strong sink for K, Ca and nitrogen. Here is confirmed that the apple peel contains a slightly more to several times higher level of many bioactive. This is especially exposed for calcium in peel tissues, where its concentration is important because that low levels in apples can cause physiological disorders as bitter pit and flesh browning disorder. The concentration of magnesium and sulfur differs between peel and apple flesh too, but for the phosphorous content it could not be said. All investigated microelements varied in their content between these fruits parts, while peel was dominant sink for Fe. Other microelements (Cu, Mn, Co), combined with metals (As, Cd, Cr, Hg, Ni, Pg) was distributed randomly between these two organs, what is of a great importance, because they belong to the group of "heavy metals", as potentially toxic to the humans. None of them exceed a threshold limit, dispute that soils in Norway are formed on alkaline and metamorphic bedrocks, which usually contains a huge quantity of metals.

The key problem of Norway apple production is potassium which is greatly dependent on this element. The soil organic matter reserves are not considered as a reservoir of this element,, thus K should be applied by mineral fertilizers. Therefore, its available presence in tested soil varied between low or extremely high, so, a K fertilizer recommendation should balance this polarity in Norway orchards.