Climate change from the aspect of crop producing farms

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Abstract

The effects of climate change cause major challenges for farmers. The more and more extreme weather, the change of temperature, the dry seasons, the amount and unequal distribution of precipitation often demands the application of new technology from the farmers. The authors analysed the main production elements, sowing structure, climatic data and machinery at 5 farms. The analyses found that multiple farms carried out technical developments and purchase of equipment, but the acquisition of modern machinery required significant financial resources. The authors introduce what sort of technological modifications have been carried out by the experts in terms of the reduction climate change effects, involving sowing structure, tillage, plant protection, irrigation and harvesting.

Keywords: climate change, weather, technology, technological development

Introduction

Climate is a system of weathers of a longer period, including extremities. It includes temperature, precipitation, wind and cloud formation...” (Net1). This complex system is affected by both external influences (natural factors) and human impact: „modification of the composition of the atmosphere caused by greenhouse gases and particles or by tillage and changed soil use.” (Net1). As a result of climate change previously unknown pests and diseases might appear and cause large damage, as experts do not know the method of defence (*Kocsis* and *Anda* 2010). According to forecasts, frequency and duration of extreme climatic and water balance situations – flood, internal water, over-moistening and drought – will increase and their consequences become more serious (*Várallyay* 2010). In the plain area of Hungary the risk of both internal water and drought is present, the latter makes farming difficult mainly on the Great Plain and the Tisza area. However, soil conditions are affected by numerous other factors as well, including improper agro-technology (*Pálvölgyi* and *Csete* 2012). *Biacs* (2011) points out the above when explains that temperature increase caused by climate change is mainly characteristic in the eastern and north-western parts of Hungary. According to the author, drought tolerant varieties should be preferred for cultivation.

The multilateral functionality and productivity of soil are limited by many hindering factors: drought, nutrition stress, excessive moisture conditions. Expansion of areas utilised by production is not easy due to the increasing number of obstacles. There are examples when we need to settle with adaptation to the degrading conditions (*Németh* and *Várallyay* 2015). The latter has to be emphasised, because preservation of the natural resources, soils and ecosystems of Hungary, maintenance of their functionality and their reasonable utilisation are major elements of sustainable development (*Várallyay* 2010). According to *Birkás* and *Jolánkai* (Net2), the most important tasks of decreasing climatic damage include the creation non-compacted soil conditions or its preservation and in the case of compaction proper subsoiling, without the creation of a water losing layer. The surface has to be covered with grinded stubble residue in order to protect to soil and its humidity, to reduce heat stress and to shorten the period between seed bed creation and sowing. Against water loss, it is reasonable to finish after ploughing, and also to apply mulching. The cost effective mulching involves leaving the stem residue on the soil (*Nagy* 2014). As modern cultivation requires high performing agricultural machinery and the increase of performance is accompanied by the increase of their weight, the physical impact on the soil are also intensifying. Therefore, compaction needs to be reduced for example through the reduction of tillage interventions. The options of preserving soil moisture include harrowing and the application of a cultivator (*Nagy* 2014). Reduced tillage – under dry circumstances – might be the best solution (*Net3*). In severe climatic conditions (ice stress, rain stress) cultivator-based tillage is recommended instead of ploughing (*Birkás et al.* 2012). Ploughless tillage is also advantageous in terms of other aspects, as the mulch left on the surface provides perfect conditions for earthworms. Spreading of mulch does not require extra labour, because it is carried out together with harvesting. The activity of earthworms results in better soil structure. Based on the above, cultivation is of high significance; this is pointed out by the German experiences of *Barczi et al.* (2015). They found that 18–25 cm deep cultivated layer of the previously ploughed upper soil was explicitly loose.

Crops react differently to the extreme climatic conditions.

Cereals, peas and oil crops are less sensitive to these conditions; they are less affected even by the extremities. However, they are more sensitive to agro-technology and sowing structure. Maize and potato are more sensitive (their original climate differs from ours the most). The effect of weather is the most visible in the case of alfalfa and sugar beet. Meteorological factors: temperature, precipitation and radiation are important, but agro-technology and other elements are to be taken into consideration as well (*Tarnawa et al.* 2010). According to *Pepó et al.* (2015), the change of sowing date in the case of green peas results in different average yields. Late sowing resulted in less yield (late sowing was a negative effect on yield). According to *Nemeskéri et al.* (2015) early green pea varieties are less sensitive to drought. *Szabó* (2014) analysed sunflower and found that later sowing dates result in the increase of yield in rainy and extremely rainy years, however as a result of drought the yield result of early sowing have been below optimally and late sowed plots, while yield maximum was provided by optimal middle April sowing. According to *Ragán et al.* (2014), the proper selection of sowing time is important in the case of maize as well; multiple factors have to be taken into consideration: general heating, heating characteristics of the soil, weather. Weather is the most important factor of uncertainty. Temperature affects the date of harvesting as well; work can be started earlier when average temperature is higher (*Erdős* 2015).

As the reduction costs might contribute to the market access of farms, modern technical infrastructure supports the achievement of competitiveness (*Harsányi et al.* 2005, *Ványiné et al.* 2012, *Sulyok et al.* 2013). The importance of technical modernisation is well characterised by the fact that amongst agricultural investments the purchase of machinery increased by 34% in 2011 compared to 2010 (*Ministry of Rural Development* 2012).

Certain types of modern equipment allow precision farming. Its advantage that there is no overlapping between the operations, therefore less fuel, seed, chemical is required (*Avar* 2015). One of the options of climatic protection is related to the above: the rationalisation of nitrogen fertilisers in agriculture (*Pálvölgyi* 2000). The listed advantages might justify the future spread of this technology and general technological development.

Materials and methods

The analyses have been carried out in Hajdú-Bihar county at 5 farms (Farm1 – Farm 5) (F1 – F5). Characteristic sowing structure, available machinery and the used technology for the reduction of the effects of climatic extremities have been evaluated. The most important meteorological data has also been collected for multiple years back. As the reduction of tillage, sowing, plant protection and irrigation require new and modern equipment, the farms carried out technological developments. The developments required significant resources, therefore the volume of these developmental resources have been evaluated as well.

Data collection was carried out through interviews and document analyses. Our results are represented by tables and figures.

Results and discussion

Figure 1 shows the proportion of the area size of each analysed farm, where F1 was the largest amongst the 5 farms, almost twice as large as the next one. The main cultivated crops are introduced in *Figure 2*.

Figure 1. *Area size of the analysed farms*

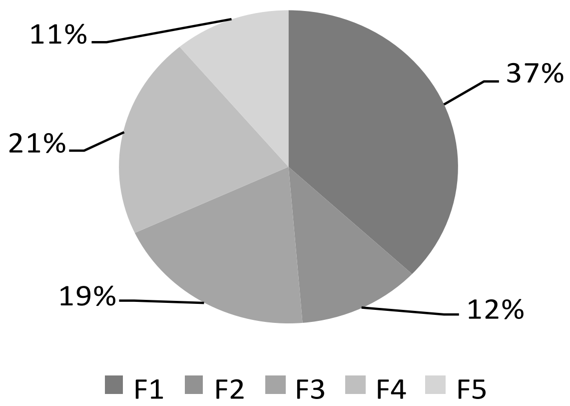
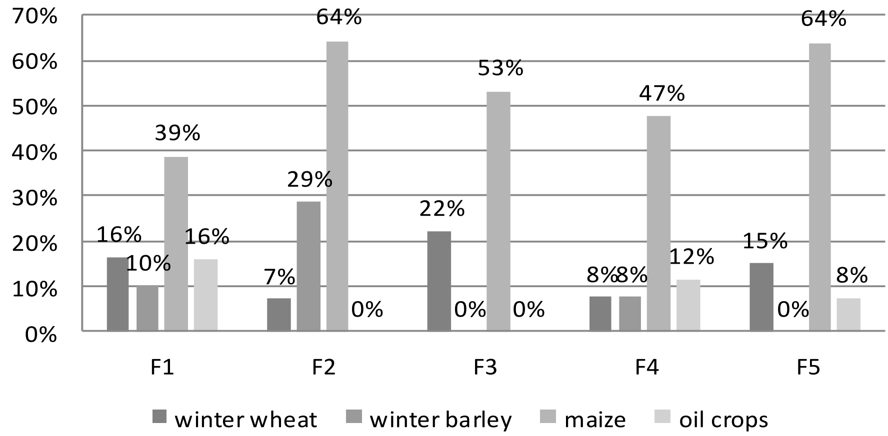


Figure 2. *The main crops produced by the analysed farms*



The *Figure 2* shows that maize and cereals occupy significant production areas in the case of every farm. The sown area of maize is even higher, it is produced on almost two-third of the total area by the F2 and F5 farms. This is in harmony with the proportions of the produced crops in Hungary, because in 2014, on 27% of the total are wheat, on 29% maize has been produced (*Net4*). Additionally, the production of oil crops is also important it involves three of the farms.

According to the information of the data collection, the following crops are produced for foraging: maize for silage, winter barley, alfalfa and grass in F1, cereals and maize in F2, maize and alfalfa in F3, cereals, maize, alfalfa and grass in F4 and all the crops in F5.

Temperature and precipitation are amongst the sensible and measurable characteristics of climate change. They are represented by *Figure 3–4*.

Figure 3. *Temperature data of the last 10 years*

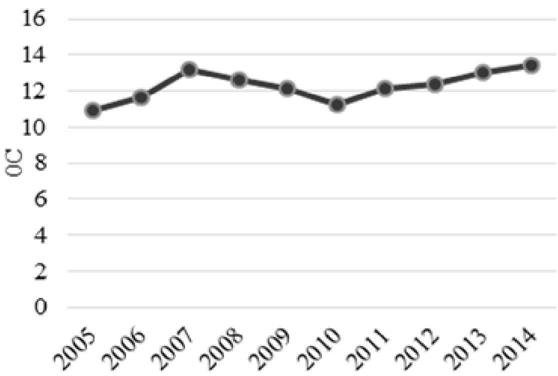
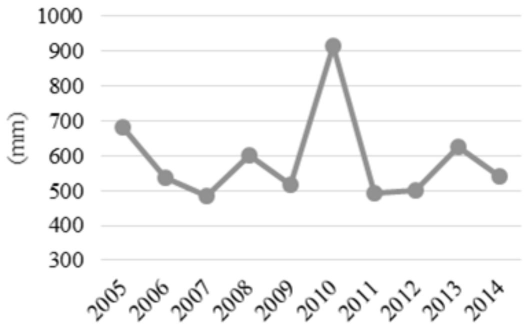


Figure 4. *Precipitation data of the last 10 years*



As shown in *Figure 3,* temperature increased by 2 ºC during the last 10 years, while the precipitation data shown in *Figure 4* represent significant yearly fluctuations. It is important that in 2010 precipitation exceeded 900 millimetres, which – according to experts – strongly hindered cultivation which resulted in 20% of the previous income.

As a result of the droughty weather of the last 11 years experts modified the sowing time of maize in order to bring flowering sooner, and because of the better moisture conditions of the soil (*Table 1*).

Table 1. *Change of maize sowing dates in the F3 farm*

Years	Sowing date (month/day)	Years	Sowing date (month/day)
2005	04. 16.–05. 04.	2011	04. 10.–05. 04.
2006	04. 30.–05. 15.	2012	03. 31.–04. 20.
2007	04. 04.–04. 22.	2013	04. 22.–05. 01.
2008	04. 11.–05. 01.	2014	03. 26.–04. 17.
2009	04. 07.–04. 22.	2015	04. 08.–04. 20.
2010	04. 03.–04. 26.		

As the *Table 1* shows, sowing dates during the last 11 years differed from the previously applied practice (20^{th} April–5^{th} May) and sowing took place mainly in April. In 2012 and 2014 sowing started at the last week of March and was finished by the middle of April. Sowing dates were earlier in the F5 farm as well; they start it around the 10^{th} April, because soil moisture content is more favourable then.

The weather changes of the recent period and its extreme nature forced farmers the react to the new situation in terms of tillage and its machinery. This is detailed and introduced below by comparing each farm.

Stubble stripping and soil preparation have a major effect on the preservation of soil moisture. The experts of the analysed farms agree on this. Therefore, this work is carried out with harrow and roller. Ploughless tillage is preferred more and more in every farm; it is applied for multiple crops. Ploughing is carried out 5 cm shallower in F5, but they intend to plough less frequently. The F2 farm applies a slotted steering plate plough, which has the advantage to carry out proper work even with high soil moisture content and also has a higher daily performance. The F4 farm uses a medium deep sub-soiler and mulch cultivator instead of ploughing. Four of the five farms (F1-F4) have RTK-system (Real Time Kinematic), which is applicable for multiple operations. Strip tillage is used in 2 farms (F1-F2). Ploughing is also finished in a single pass at F3, and as a result of medium deep subsoiling a single pass is sufficient for soil preparation instead of multiple ones.

It is generally found, that farms purchased high performing power engines and therefore they are able to use larger tools and use less passes which reduces compaction of the soil.

For the application of fertilizer (liquid manure) F1 and F4 farms use tank trucks equipped with injector and slipping pipe, while the F2 farm uses a plunger pipe injector. In the F3 farm fertilizer is applied in a single pass with a seed bedder combinator. In the F5 farm, the dispenser is mounted onto the cultivator.

Sowing is carried out with direct sowing machines in the F1, F4 and F5 farms. Consequently, soil preparation, application of the fertilizer and sowing can be done in a single pass, which results in reduced soil compaction, which causes less fuel consumption and emission. In the F2 and F3 farms semi-direct sowing machines are used, which also include a tillage tool. As a result of breeding, the used seeds are tolerant to drought.

Irrigation is not possible in the F1 farm. In F2, there was irrigation, but due to the insufficient amount of water they stopped it. They have plans for the future to find a solution to irrigate. In F3, the irrigated area was expanded. In F3 and F4, the equipment was modernised, sprinklers have been installed which results in less evaporation loss. While irrigation started from May previously, during the recent years it starts already in March, and it is done even in September. In F5, irrigation started in 2015 and they have plans to install a rotating-system equipment.

In terms of plant protection, weed control is the most significant task. It is clear that as a result of little precipitation post-emergent chemicals are used instead of pre-emergent ones. In F1 and F5 plant protection is based 100% on post-emergent chemicals, while in F2 and F3 the ratio is 30-70% form pre- and post-emergent chemicals. In F4, pre-emergent chemicals are used on the irrigated areas, while post-emergent ones on the non-irrigated areas. Mobile sprayers have been purchased by four of the five farms (F1, F3, F4, F5).

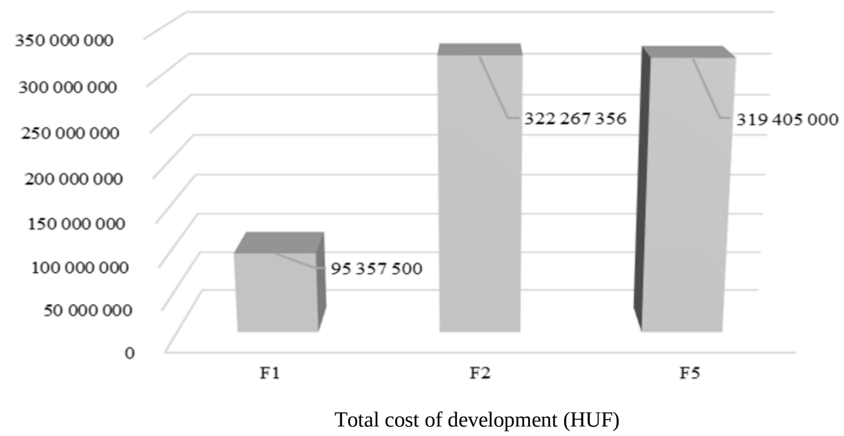
A modern harvester has been purchased by F3 and F4.

Maize is harvested crushed in two farms, therefore harvesting can be started earlier and preservation is carried out via lactic acid fermentation. In F2, some of the dry maize is harvested as grain and is stored in silos, while it is being cooled. In F5, some of the maize is used as silage, with the help of external contactors.

For transportation, only one farm (F2) uses a transfer vehicle, which – as a result of its larger tires – compacts the soil less and increases daily performance as well. It is reasonable to use a transfer vehicle, because other vehicles that are suitable for road traffic do damage to the soil as a result of their smaller tires. In the rest of the farms conventional machinery is used (power engine with a trailer or a truck) for the transfer of the harvested product. This is carried out by external contractors in the case of F5.

As a result of the changed and sometimes extreme climatic and soil conditions the purchase or modernisation of the modern equipment of the above operations became necessary. Significant resources have been utilised for these developments (*Figure 5*). (The figure includes only 3 farms, as 2 did not provide data about investments; however they carried out major acquisitions of machinery as well.)

Figure 5. *Machinery acquisitions of three analysed farms (HUF)*



It is shown that the F1 farm carried out a smaller investment than the other; however its productive area is the largest amongst the analysed farms. The other two farms are the smallest and their total amount of investment exceeded 300 million HUF.

Conclusions

- The experts of the analysed farms agree on the extreme signs of climate change.
- On different levels, but every farm made efforts towards the avoidance of compaction and single pass tillage.
- The farms try to focus on the preservation soil moisture and the avoidance of compaction in the case of more and more operations.
- One of the methods of adapting to the consequences of climate change is earlier sowing in the F3 and F5 farms.
- The analysed farms carried out different technological developments during the last 5–10 years for the sake of modern farming.
- The analysed farms are characterised by careful production and innovative view.
- Despite of the sensible effects of climate change, the farms try to maintain or improve their yield levels.

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