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INFLUENCE OF FIELD EXTENT ON CULTIVATION COSTS

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ABSTRACT

The paper deals with the influence of main spatial characteristics of a field extent such as area, length and width, on cultivation costs. Performed analysis allowed to determine proper parameters of a field extent i.e. parameters whose further improvement generates insignificant lowering of cultivation costs. The parameters depend on the function describing cultivation costs, namely on the occurrence of minima and horizontal asymptotes. The determined parameters were based on general tendencies ruling the relationships in question. For a properly

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formed field on which low and medium tractors are used, the following values for the proper parameters were found: more than 150 to 250 m of length, over 30 to 70 m of width and the area bigger than 1 to 2 ha.

Key words: field extent, cultivation cost, farmstead, spatial arrangement of farmstead territory

INTRODUCTION

Spatial arrangement of a field, called the field extent, influences the productive processes taking place within the field in question. In search of the maximal productivity two approaches have been applied: either the concerned field extent has been exploited according to the good cultivation practice and apt technology, or the most effective field extent is sought. The relation between the field extent and the income its cultivation produces can be expressed in terms of field extent cost which includes all the costs and production losses that depend on the spatial conformation of the field in question. Fluctuation of such cost resulting from a change in the field extent are transformed directly onto the income brought by the cultivation.

The production costs for a field, or losses, can be divided into three main groups with respect to the field extent as presented by Stelmach 1975, Lasota 1980, Porta 1983 and Harasimowicz 1992:

- losses and costs related to the width of the field (turn-backs, managing the turn-back lane, production losses due to the field width) – z_{bd},
- losses related to the length of the field (production losses near the boundary of the field all along its length) – z_l,
- cost of transport within the field related to the field length and area – *R*.

The cost for a given field extent for a field characterised with area *p*, length *l* and width *b* can be calculated according to the following formula:

$$K_r = z_l l + z_{bd} b + R \frac{1}{2} l \; p \qquad (1)$$

Despite troublesome estimation of particular parameters for the equation (1) leading to inadequate value of costs per field extent, the presented procedure for determining the costs has been widely accepted. Since the parameters depend on many factors such as the production method, quality of the roads, as well as location of the site with respect to fields, determining their actual values requires extensive and time-consuming field surveys.

Due to such difficulties, so far in Poland the parameters necessary to calculate the cost for a field extent have not been found by field studies extensive enough to provide a reasonable base for their proper determination. Few studies performed on specific plants and cultivation technologies tried to estimate the parameters but usually they included no empirical research of the production process. Usually studies were concerned with adjustment of a foreign standard value [Stelmach 1975, Harasimowicz and Ostrągowska 1996] or theoretic considerations [Dembowska, Lachert 1974].

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Currently to estimate the extent parameters for fields, plots, and farms either the parameters defined in other European countries, especially from German-speaking, adopted to Polish conditions are applied, or the problematic values are estimated by a professional and experienced agricultural field surveyor [Hopfer 1991]. The lack of data on reliable values of field extent parameters which allow to determine its potential influence onto the productive processes, remains to be a serious impediment both for shaping spatial configuration of fields and assessing spatial rearrangements performed, as well as for pricing allotments where the field extent value can contribute up to 30% of the total worth [Hopfer 1991]. Analysis of parameters calculated according to standard values adopted from other European countries [Harasimowicz, Ostrągowska 1996] proved that it is possible to track major factors shaping the field extent that have resulted from major tendencies in-between the cultivation cost and spatial arrangement of fields.

The presented considerations will follow mainly the goal to define parameters that determine the range of proper shaping of the field extent. The proper value of a field extent can be defined by changing the main field characteristics within the limits for which the relevant cultivation costs are relatively low and cannot be substantially reduced by further improvement of field parameters. The limits can be defined by determining functional influence of a particular field characteristic upon the cultivation cost for the field extend in question. Such a range of particular field extent characteristic will be covered, within which little values for costs of the field extent are found and their fluctuation are insignificant. Occurrence of horizontal asymptotes or functional minimum coincide usually with such ranges.

CULTIVATION COSTS VERSUS LENGTH AND WIDTH OF FIELD

Analysis of field extent cost can be facilitated by expressing its values per unit area. Interpretation and comparison of costs for fields of different areas are then simpler and more evident. If we divide both sides of the equation (1) by the field area, the resulting function will define the expenses for a field extent recalculated per unit area of the field with respect to its length and width.

$$k_r = \frac{z_l}{b} + \frac{z_M}{l} + \frac{1}{2} R\, l = K_1(b) + K_2(l) \quad (2)$$

The function is a sum of two addends, each of them dependent solely on either the width or length of the field. Hence, both width and length of the field influence the cultivation cost individually. Consequently, the losses made on short and long fields are the same if only they are related to a specific, unfavourable field jwidth. Similarly, lowering in the cultivation costs resulting from a comparable rise in a field width, will be equal for fields of different length. That particular property is of great practical value when it comes to field division. It should be clearly realised that it is impossible to reduce the unfavourable influence of one of the considered parameters upon the cultivation costs by changing the other. In particular, it would be impossible to balance the harmful influence of deficient width by elongating the field.

Fig. 1. Influence of the field length and width on the cost of a field extent; crop rotation with cereal, 55 KM tractor, soil-surfaced roads, both sides of the field accessible from the roads

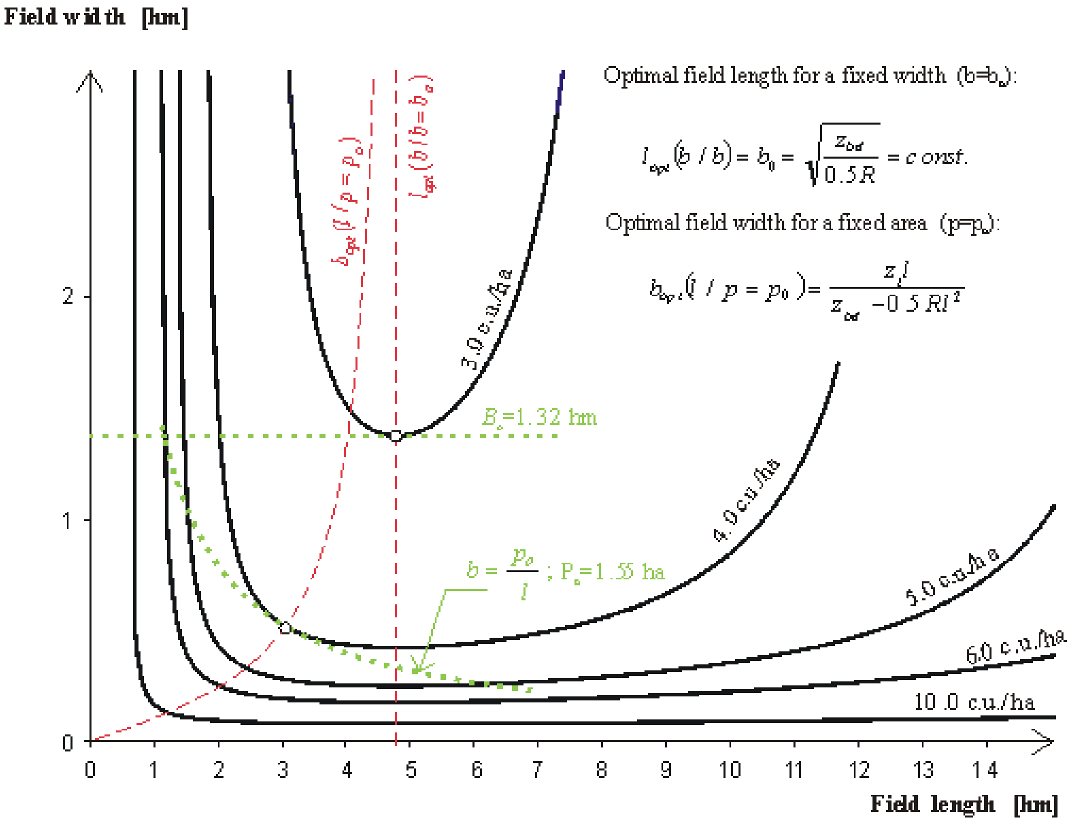


Figure 1 presents an exemplary plot of the function expressed by the equation (2) in a form of curves of equivalent field extent cost (i.e. isoquants). High cultivation costs are observed for fields of little length and width. With the width increasing, the costs at first fall rapidly, only to reach the constant level then. Though the increase in field length leads to a great reduction of cultivation costs, they begin to rise slowly once the minimum has been reached. Two lines representing the width and length for which the cultivation costs are minimised, for a fixed area or width of the field.

The optimal field length for a fixed width can be expressed as follows:

$$l_{opt}(b / b = b_o) = \sqrt{\frac{z_{bd}}{\frac{1}{2}R}} \qquad (3)$$

The function is plotted with a dotted line in Fig.1 and reveals a linear dependence: a line is parallel to the vertical axis. The line is the axis of an asymmetric valley created by the function expressed by equation (2). It crosses points of tangency of the isoquants for the field extent cost and the lines parallel to the horizontal axis which correspond to a fixed field width. Let us analyse the isoquant which defines the combination of width and length of the field, for which the field extent cost amounts to 3 cereal units per ha (c.u.·ha^{-1}). It is tangent to a line corresponding to fields of 132 m of width. The considered point of tangency gives the optimal value for a field width since for any other value the cultivation costs will be higher.

For a fixed area of the field, the optimal width as a function of field length, can be found from the equation (2) in the following way:

$$b_{opt}(l / p = p_0) = \frac{z_l l}{z_{bd} - 0.5 l^2 R} \qquad (4)$$

The function in Fig.1 crosses the isoquants of the field extent costs at their points of tangency with the lines defining a given area of the field plotted against field width and length. For the isoquant of the field extent corresponding to 4 c.u.·ha^{-1}, the line is tangent to a hyperbola defining the width and length for the field which area is equal to 1.55 ha. The point of tangency of the two curves defines the width and length for a field with the area of 1.55 ha, for which the costs of the cultivation are minimal. Any other dimensions for a field of such area will result in employing the isoquant of higher field extent costs of cultivation.

Another important characteristic of a field extent is the elongation of a field, which is width to length ratio. The most beneficial elongation of a field for a specified area can be obtained from the formula:

$$\frac{b_{opt}}{l_{opt}} = \frac{z_l + 0.5 R p_0}{z_{bd}} \qquad (5)$$

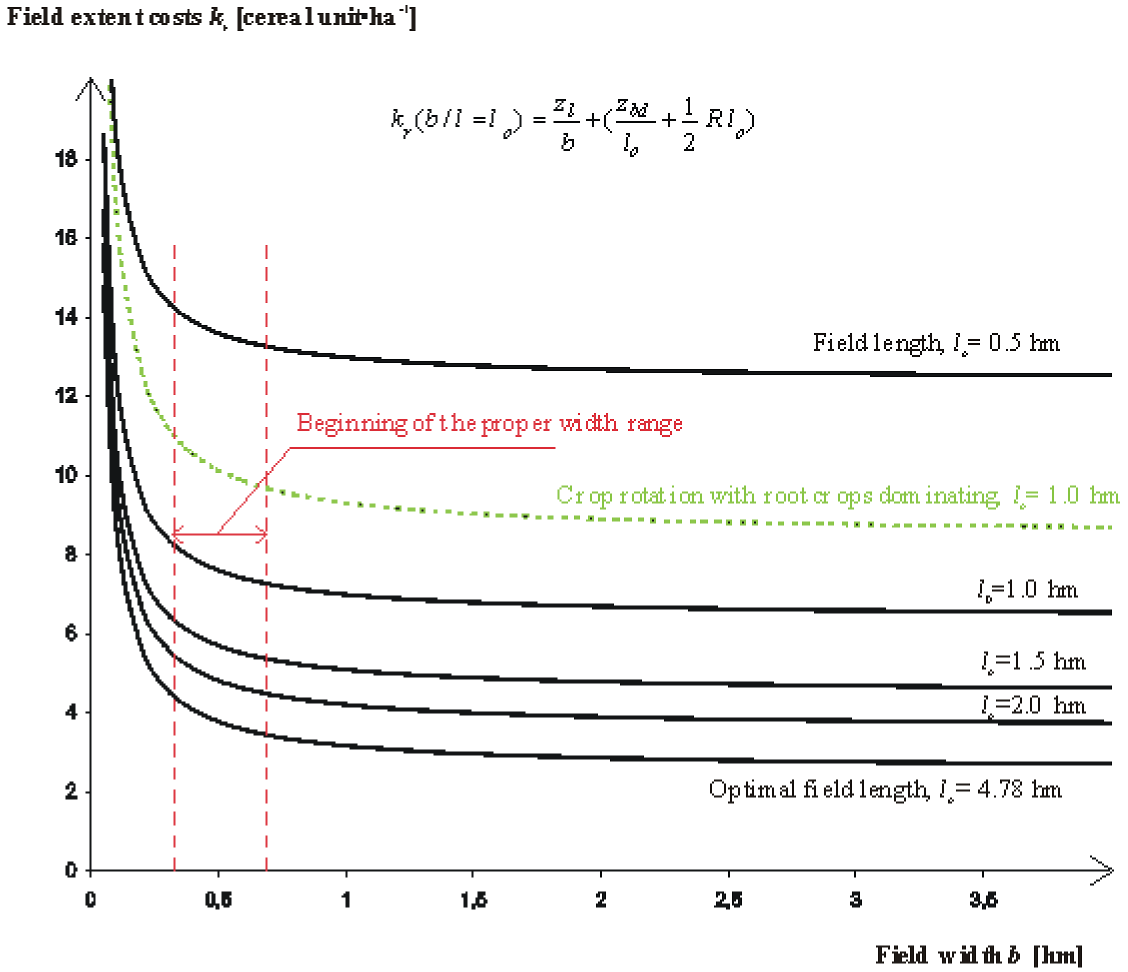
The optimal value of the elongation of the field with a given area can be obtained from the function plotted in Fig.1. where the optimal field width for a given field area is determined. The required elongation value is the tangent of the inclination angle of the line crossing the respective point of the plot. According to formula (5) elongation for fields displaying optimal shape decreases with the increase of the field area (which corresponds with growing values). Therefore, for large fields, the widths are considerably longer than the cultivation lengths. Diminishing the field area leads to field elongation, the value of which approaches the ratio of the width-related losses to length-related losses. Fields of tiny areas should be characterised with the maximum elongation given by the ratio 1:10. For large family farms the beneficial elongation of fields should be 1:5. Fields bigger than 15 to 20 ha shall be designed to keep the similar values of width and length.

Dependence between cultivation cost and field width for a fixed length

Cross sections of the surface determined by formula (2) which are perpendicular to the axis representing field length shall be analysed to find the proper field length. The plots of five such cross sections corresponding to 50, 100, 150, 200 and 478 m are presented in Figure 2. The plots of identical shape are shifted along the vertical axis of the plot, which illustrates independent influence of length and width on cultivation costs. Hyperbolic shape of the plots and the magnitude of the shift, which changes with field length, are determined respectively by the first and second part of the formula defined in Fig.2.

The lowest cost for the field extent are attained for the optimal field length, which in our case is equal to 478 m. The length was limited by the power of the farm tractors. For more powerful tractors length over 600 m could be attained. At fields whose length deviate from the optimal value the actual field extent cost are higher. Fig.2 presents cultivation cost for fields shorter than the optimal length. Slow increase in cultivation costs is noticeable with the field length falling down to about 150 m at which point the increase becomes rapid.

Fig. 2. Influence of the field width on the cultivation cost for a given field area; mainly crop rotation, 55 KM tractor, soil-surfaced roads, both sides of the field accessible from the roads



Since the shape of the concerned plots is identical, changing the field width causes identical change of cultivation costs and is independent of the field length applied. Such effect results from the fact that the total cost of cultivation is influenced by width and length of the field independently. Therefore, the financial benefits originating from the widening of the field while recalculated per area unit, will give the same values for both long and short fields. For very narrow fields the cultivation costs may reach significantly high values. Increasing the field width up to 30 m will cause the costs to fall down so rapidly, that further widening over 70 m almost does not affect the cultivation cost. Field width from the range from 30 to 70 m and wider can be then taken as appropriate, since the increase in such width does not contribute to a significant rise of the cultivation costs (Fig.2). Moreover, such a determined range applies not only to the studied example, which was concerned mainly with cereal crop rotation, but can be generalised for other cultivating methods. The supposed generalisation is supported by one of the plots presented in Fig.2, namely the one concerning crop rotation with generous amount of root crops.

Determining the appropriate range for field width as width bigger than 30 to 70 m is of great practical value. The process of designing the field layout while joining lands is usually preceded by a road layout design. Field boundaries are defined both by roads already built and planned, and therefore their length is usually fixed. Still, it is possible to obtain the appropriate field extent by adjusting their width within the range determined above, i.e.

planning a field no shorter than from 30 to 70 m. It is also important to realise that designing fields, within a defined road network, wider than from 70 to 100 m can be safely neglected since it will not bring the required results with regard to low cultivation cost.

Dependence between cultivation cost and field length for a fixed width

In Fig.3 the cross sections of the surface determined by formula (2), which are perpendicular to the axis representing field width, are presented. The plots visualise the costs born for a field extent with respect to the field length, while the field width is given. The plots are of identical shape since the influence of length and width on cultivation costs is independent. The shortening of fields results in an increase in costs of their cultivation, as it is displayed by the plots presented in Fig.2; the respective plots are at a greater distance from the horizontal axis.

The lowest cultivation costs are obtained for a field of a given width, if the field length is optimal according to the formula (3).The optimal field length is constant for a given width, and therefore independent of it, and for parameters presented in Fig.3 yields the value somewhat lower than 500 m. The conclusion, though easy to explain by independent character of the influence of width and length upon the cultivation costs, remains surprising. It means, that the magnitude of length for fields of different width, shall be relatively high and typical for very large fields, i.e. kept within the range from 400 to 600 m. However, it should be remembered that the cultivation costs are also field length dependent and therefore, in specific cases, can be more effectively lowered by varying that parameter. For each field of a given length, it is possible to lower the cultivation costs by varying the length, which is independent of the field width.

Fig. 3. Influence of the field length on the cultivation cost for a given field width; mainly cereal crop rotation, 55 KM tractor, soil-surfaced roads, both sides of the field accessible from the roads

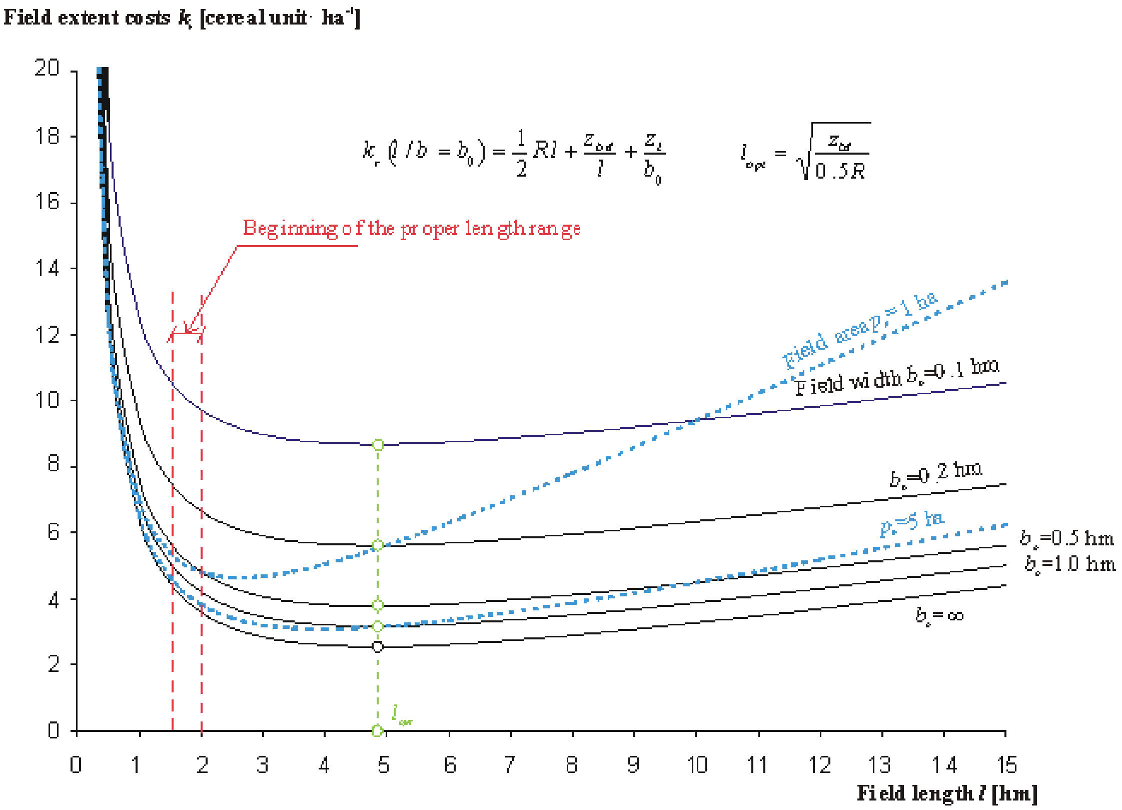


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Fig. 3 presents the absolute minimum for the cost of a field extent defined by formula (2). The minimum is reached at a field of optimal length and very large area. For such a field the cost of the field extent are slightly higher than 2 cereal units per hectare.

For fields with their width fixed, both increase and decrease in the field length with respect to the optimal one, leads to higher costs of cultivation (Fig.3). For smaller values of width than from 150 to 250 m the cost difference is especially big. Therefore, length greater than from 150 to 250 m for fields with a fixed width can be accepted as correct one. Rapid increase in the costs of field extent for fields that are shorter than 70 to 100 m, indicates that their agricultural, and in particular arable development is rather problematic [Pijanowski 1992].

CULTIVATION COSTS VERSUS AREA AND LENGTH OF FIELD

The influence of area and length of a field on the cultivation costs calculated per area unit can be expressed on the basis of the equation (1) as follows:

$$k = z_l \frac{l}{p} + \frac{1}{2} R\, l + z_M \frac{1}{l} \qquad (6)$$

The surface of the function defined by the equation (6) is represented in Fig.4 by lines of equal field extent cost. The surface is an elongated, asymmetric valley that runs in parallel to the axis representing field area. For fields characterised by small area and length, or for very long fields, the field extent costs are the highest.

For a field whose area is fixed, the equation (6) allows to determine the field length for which the cultivation costs are the lowest. Such a length, i.e. the optimal field length for a field of a fixed area, - analogous to the analysed earlier optimal field width – is expressed by the following formula:

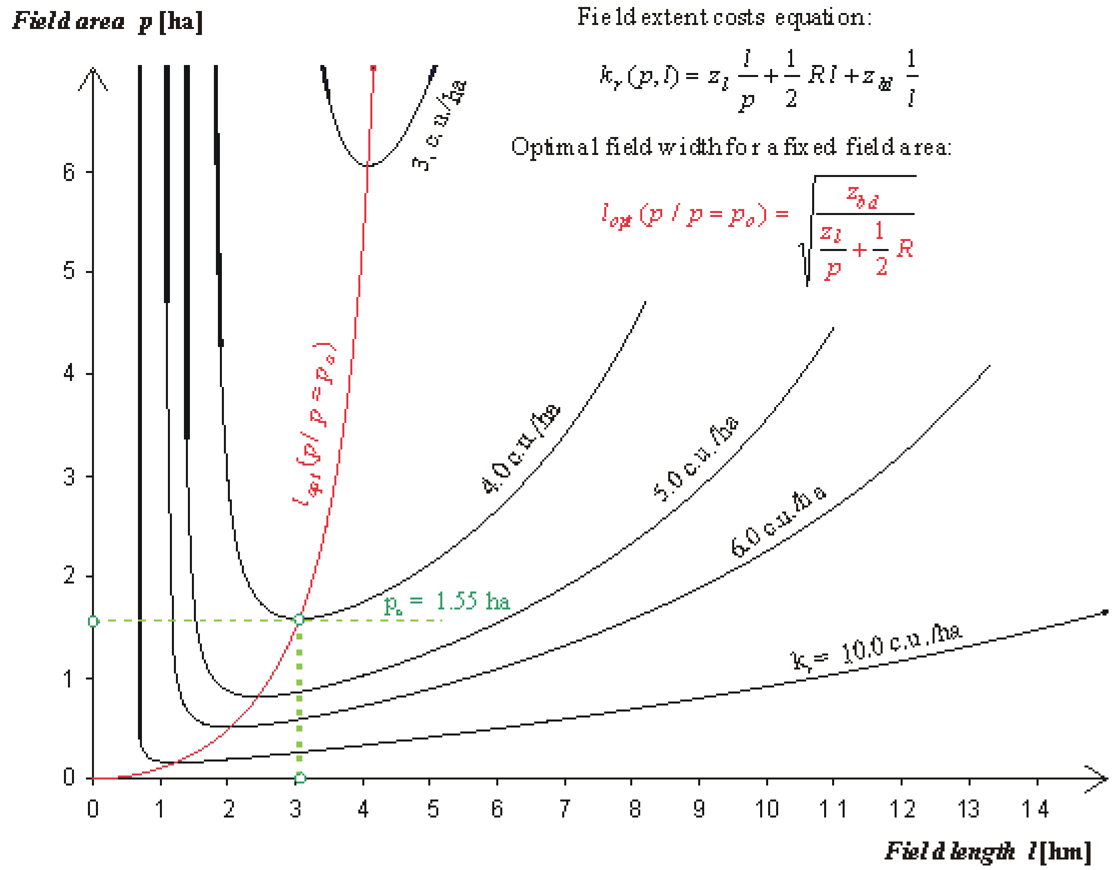
$$l_{opt}(p / p = p_o) = \sqrt{\frac{z_M}{\frac{z_l}{p} + \frac{1}{2} R}} \qquad (7)$$

The curve crossing the lines of equal field extent costs at the points of their tangency to the a straight line perpendicular to the area axis shown in Fig. 4 represents the plot of the function.

Let us consider an isoquant which defines combination of length and area of a field for which the field extent cost are equal to 4.0 $c.u.\cdot ha.^{-1}$. A line representing all fields of the area equal to 1.55 ha, marked with a dashed line in Fig. 4 is tangent to the considered isoquant. The point of tangency corresponds to the field length slightly exceeding the value of 300 m, which is the optimal length for fields of 1.55 ha, since it allows to obtain the lowest cultivation costs.

At first increasing field area causes the respective optimal field length to grow rapidly. Small fields are also characterised by the biggest elongation, which for the assumptions valid for Fig.4 and 10 acre fields reaches the ratio of 1:10. With further increase of the field area the respective increments of the optimal length become less and less significant, so that it is limited by the value characteristic for the applied cultivation technology. In the analysed conditions of using medium-power farm tractors, the length for large fields should not exceed 450 m.

Fig. 4. Influence of the field area and length on the field extent cost; mainly cereal crop rotation, 55 KM tractor, soil-surfaced roads, both sides of the field accessible from the roads



The influence that field area and field length have on the cultivation costs is interrelated, as it was in case of length and width influence. Area and length are interrelated when it comes to crop losses per field length (parameter z_l). Such losses recalculated per area unit are proportional to the field length and inversely proportional to its area.

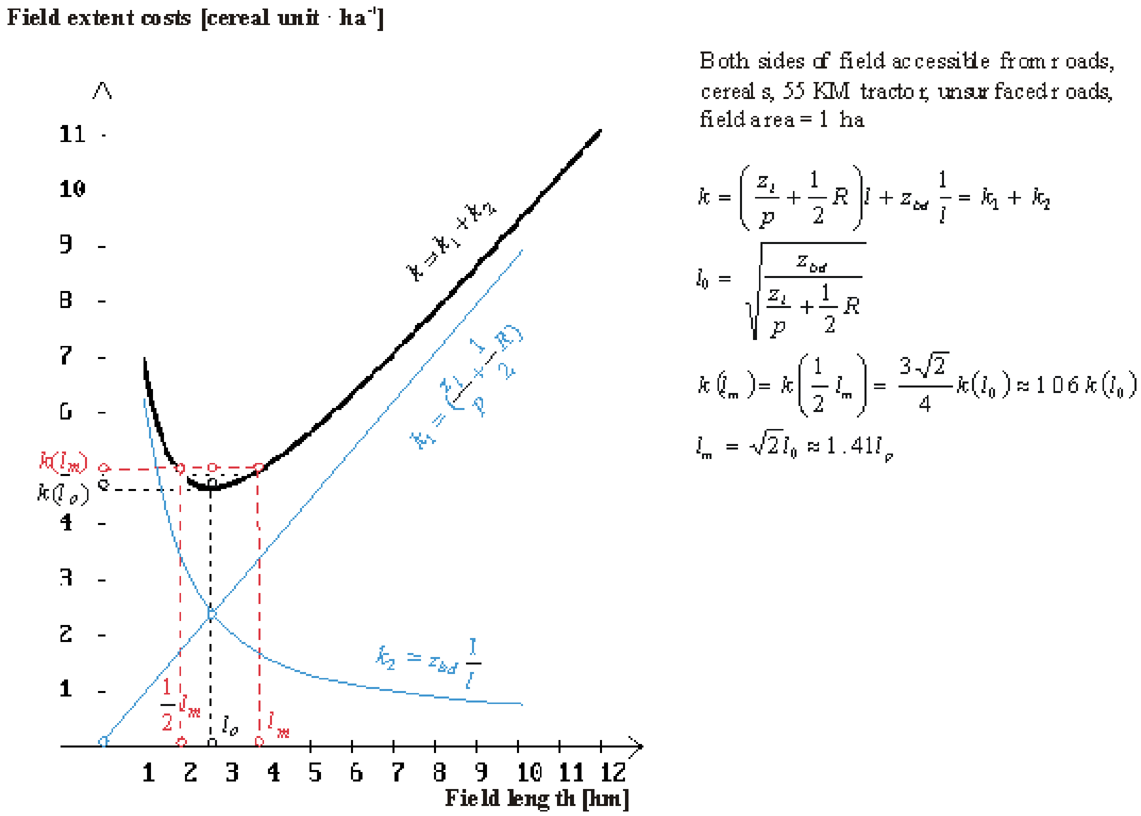
Field length-related variation of cultivation co sts for a fixed field area

The field extent costs for the field of a given area "*p*" are defined by the equation (6), which could be also rewritten as a sum, of two addends related to the field length in different manners:

$$k = \left(\frac{z_l}{p} + \frac{1}{2} R\right) l + z_{bd} \frac{1}{l} \qquad (8)$$

The first component of the equation shows a linear dependence of the field length, while the second follows the hyperbolic shape.

Fig. 5. Field extent costs plotted against the field length with the field area fixed to 1 ha



The influence of the field length on the field extent costs for a field with the area of 1 ha as an example is presented in Fig.5. The increase in field length results primarily in the significant lowering of cultivation costs. The lowest attainable costs are obtained when the part proportional to the field length is equal to the part related to the field width. The optimal field length for a given area can be expressed, as it was demonstrated earlier, with formula (7). The increment in the field length which exceeds the optimal length calculated on the basis of the equation leads to higher costs of the field extent that asymptotically approach the line describing the field extent costs that are proportional to the field length. Varying the field length in the direct vicinity of its optimal value, do not cause the field extent cost to rise. Within a specific range of field length, into which falls the optimal value, the field extent cost are small and therefore such values of the field length can be considered as appropriate.

The issue of defining the range for appropriate field length is tightly related to the problem of the right assessment of the road network density. Distances between the neighbouring roads are usually different from the values recommended for the field length to obtain the lowest field extent costs. If the distances are longer than the optimal length, a solution can be negotiated by introducing new roads in between the existing ones in order to higher the road density. Otherwise, closing of few roads may appear beneficial.

Let us analyse the following problem: how big should be the distance between the roads, i.e. the length of the field, for which introducing a new road proves profitable. The field extent costs for the obtained in such a way length shall be greater or equal to the field extent costs for a field whose length is reduced by half. If l_m stands for the maximum distance between two roads whose dividing is not profitable, such a distance, further referred to as the maximal field length, shall fulfil the condition:

$$k(l_m) = k(\frac{1}{2} l_m) \qquad (9)$$

Solving the above equation we will obtain for l_m:

$$l_m = \sqrt{\frac{z_{bd}}{\frac{z_l}{2p} + \frac{1}{4}R}} \qquad (10)$$

Further comparison of l_m with the optimal field length l_o leads to:

$$l_m = \sqrt{2} l_0 \approx 1.41 l_0 \qquad (11)$$

Hence, the maximal length of a field, for which no division by road is required, and the optimal field length is independent of the parameters included into the field extent equation. The maximal field length is by 41% longer than the optimal value.

Half of the maximal field length is the minimal distance separating the road from the neighbouring ones, for which the road should not be demolished. Such a length is called the minimal length.

$$\frac{1}{2} l_m \approx 0.71 l_0 \qquad (12)$$

The minimal field length is smaller than the optimal length by about 29% and the percentage is independent of parameters determining both the field extent costs and the field area.

It can be proved that the ratio of two field extent costs corresponding to the maximum (minimum) length and to the optimal length, does not depend on parameters of the equation of the field extent costs and equals

$$\frac{k(l_m)}{k(l_0)} = \frac{k(\frac{1}{2} l_m)}{k(l_0)} = \frac{3}{4}\sqrt{2} \approx 1.06 \qquad (13)$$

The field extent costs for the maximal length of the field are higher than the field extent costs for the optimal length by a mere 6%. It seems reasonable enough to accept the minimal and maximal length as the limits of the range for correct length of fields. Therefore, for each field area such parameters as the maximal l_m and the minimal length (l_m shortened by half) can be determined. Fields with length falling into the range [1/2 l_m, l_m] shall be assessed as formed properly, and the field extent cost for them are higher than the minimal field extent costs by no more than 6%.

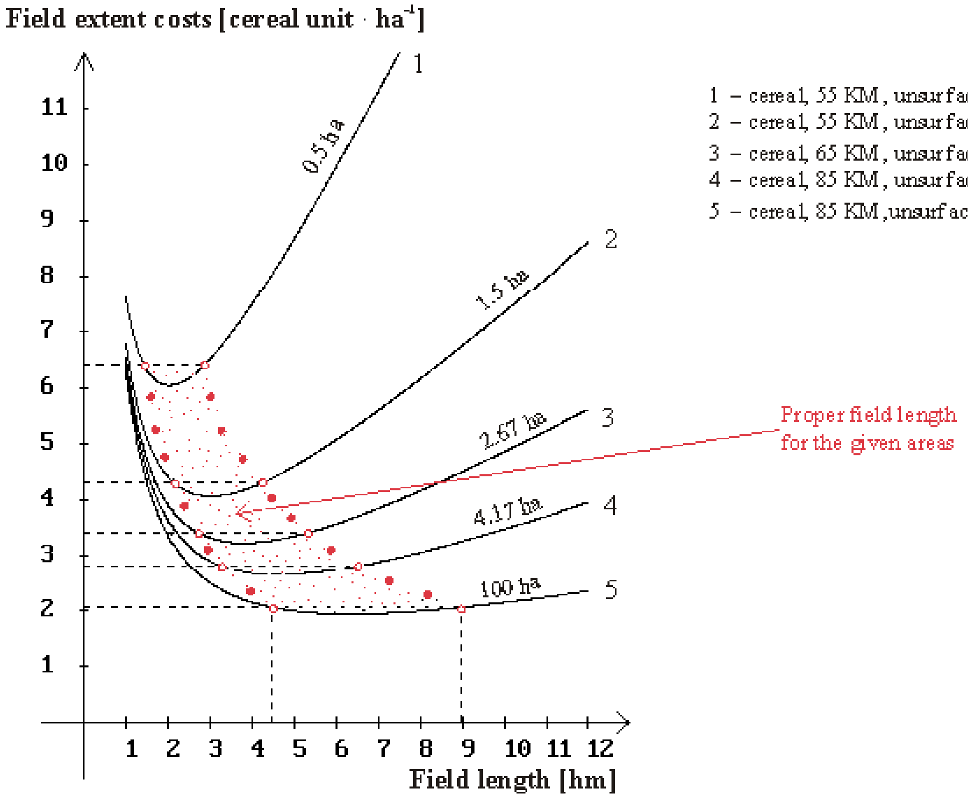
The defined above range of field length established as appropriate for a given field area allows such correction of the road network that facilitates designing fields of the required length. It could be achieved either by designing new roads inbetween the existing ones, or closing the roads that have been in use already. Additional roads should be designed when the distances between them exceed the upper limit of the rational length range. The roads shall be abandoned whenever they lie inbetween roads whose distance from each other is shorter than the mentioned limit.

The area of a field influences the optimal length and the range of appropriate field length as well. Such impact for fields on which mainly cereal crop rotation have been applied is presented in Fig.6. The fields in question can be accessible by unsurfaced roads from their both sides. Tractor power varies from 55 to 85 KM and in general is adjusted to the size of farms and fields.

The increase in the field area is related to the increase of the optimal length. The scale within which the respective limits for the appropriate length ranges vary, is very similar. Length for fields whose area is equal to 0.5 ha. should by no means be shorter than from 150 m and longer than 300 m. For fields of the area equal to 4.17 ha. fields cultivated by means of 85 KM tractors can be longer and measure from 300 to 600 m.

The wide range of appropriate field length, explains possibly the right assessment of the field extent made by the owners, though the spatial arrangement of their allotments varies within great limits and deviates from the optimal one quite significantly. The same reasons clarify the lack of interest put to joining the lands. Such situation takes place whenever a relatively wide range of field extent improvement brings minor economical effect. Such land merging is more effective in clarifying the property status rather than improving the production profitability.

Fig. 6. Ranges for proper field length depending on the field areas (mainly cereal crop rotation, tractor power suitable for the field size, soil-surfaced roads, both sides of the field accessible from the roads



Differences in the field length within the range of correct magnitudes correspond to immaterial change in the income that under typical conditions reach about 0.5 c.u.·ha^{-1}. However, taking into account more significant differences of cultivation cost, makes possible to determine more universal region of correct field length which is not so highly area-dependent and is neatly related to the findings illustrated in Fig.3. For fields of areas bigger than 1 to 2 ha. the beginning of the weak field length influence upon the cultivation costs falls into the range of 150 to 250 m (Fig.6). For fields of areas smaller than 1 to 2 ha. increasing length is accompanied by excessive drop of width, which leads to significant increment in the cultivation costs. The right assessment of the length for such fields should be carried out in conjunction with their correct length calculated according formula (11) and (12).

The increase of the cultivation costs is observed not only for too short fields, but also – though in a narrower range - in case of too large increment in the length. The overrated increase in the field length, namely over 800 to 1000 m, is restricted by the village dimensions and it is rather insignificant for fields of large area whose correct length are usually quite large. Therefore, the increase in the cultivation costs caused by excessive elongation of fields can occur only for too small fields whose area is under 2 to 3 ha. For the field areas determined as correct, i.e. larger than 1 to 2 ha., it is enough to keep the elongation ratio as 1:10 to maintain the required field extent costs. Thus, the whole correct length section for fields larger than 1 to 2 ha. contains fields characterised by length bigger than 150 m to 200 m and elongation ratio over 1:10. In such a zone the increment in the field extent cost should not exceed 1 to 2 c.u.·ha^{-1}.

Field area versus field extent costs for a fixed field length

Growing field area for a fixed field length causes the cultivation cost of a field to fall down (Fig.7). The larger is the field, the smaller are costs of its cultivation. Nevertheless, the cultivation costs borne at a field are not the major presumption while determining the field size. The field area depends mainly on the farmstead size, which in turn is shaped by a number of factors related to the farm productivity, and circumstances of social and political character. Each field is divided into smaller parts with regard to the assumed crop rotation. The tendency presented in Fig.7 shall imply division into largest fields attainable, since it favours lower cost of their cultivation.

Fig. 7 presents 4 plots of functions describing the changes in the field extent costs related to the field area for the constant length of 50, 100, 150, and 400 m. The envelope of the function of such type is a bolded line depicting the influence of the field area of a fixed area upon the field extent cost borne. The plot is defined according to the system of equations (6) and (7).

$$k(p/l = l_{opt}) = \sqrt{2z_{bd}R + \frac{4z_l z_{bd}}{p}} \quad (14)$$

The concerned plot represents the lowest field extent costs attainable at the given area. It is the cross-section of the field extent cost surface presented in Fig.6 along the line that determines optimal field length for each field of a given area. The remaining curves illustrate the increase in cultivation costs related to the departure from the optimal value, thus aggravation of the field shape.

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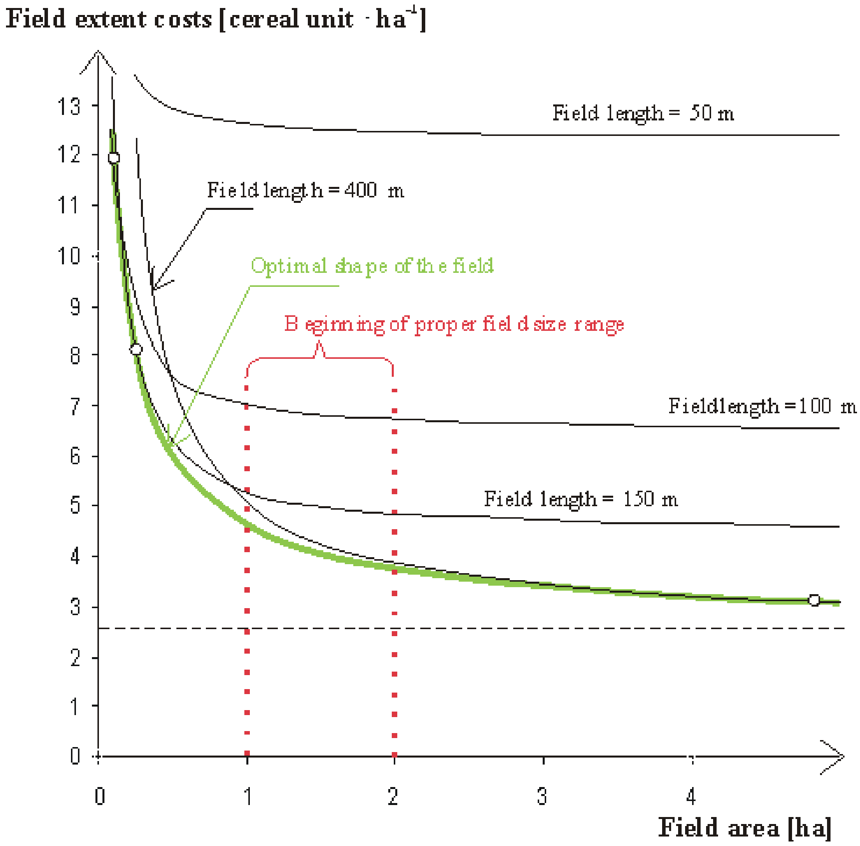
Fig. 7. Influence of the field area on the field extent cost; mainly cereal crop rotation, 55 KM tractor, soil-surfaced roads, both sides of the field accessible from roads



For the plot illustrating the field extent costs for fields of optimal length, the beginning of the zone of a weak influence of the field area upon the costs of its cultivation can be set within the range area of 1 to 2 ha. The zone overlaps with the initial part of the range for the proper field area. The remark remains valid for the remaining plots presented in Fig.7, the shorter is the field, the lower lies the beginning of such a zone. For the fields of areas larger than from 1 to 2 ha the possibility to reduce the field extent costs by enlarging the field is therefore hardly effective and does not exceed 1 to 2 cereal units per ha, which can be estimated as about 5 to 10% of the total income. Apart from the discussed 'weak zone', a zone of strong influence of the field area upon the cultivation costs can be found for fields with areas smaller than 1 ha. Theoretically in that zone, the cultivation costs are highly area-dependent and increase rapidly with diminishing field area.

A properly formed field for the area of 1 ha is 50 m wide, and over 200 m long. According to the assumptions made earlier such length and width of a field, can be recognised as the correct ones. Thus, a properly formed field is characterised by a proper field area, i.e. proper length and width, and vice versa: fields of proper length and width produce the area which falls into the right size field category.

The procedure for finding the proper field area for a fixed field length (or width) differs slightly. The proper area of a field is the one for which the field width is proper, i.e. a bit over 30 to 70 m. For a 1000 m long field, the right area amounts to about 0.5 ha., a 1000 m field is properly formed when its area is larger than 5 ha. Such estimation related to a 100 m field is confirmed by the relevant plot in Fig.7.

For fields smaller than 0.5 to 1 ha. the right length and width are not attainable due to too modest a size. Regarding the fields whose area is improper and therefore low cultivation costs are unattainable, their right length and width can be referred to in terms of their right form. Optimal and correct field length and width for a specific field area and their corresponding width can be calculated from the formula (7), (11), and (12). The ranges for the right length (and width) of the field with a defined area are of major significance only for fields smaller than 1 ha. For fields larger than 1 to 2 ha. the lower limit of the respective ranges is comparable to or slightly over 250 m; so it overlaps the 'universal' zone of correct field length, which allows greater variation of cultivation cost for fields of different areas.

CONCLUSIONS

The analysis of the dependency between spatial characteristics of a field and the costs of its cultivation allowed to determine the proper parameters for the field extent, which serve as the major standard for the assessment and development of land. As correct field extent parameters we define such that improved further do not significant lower the cultivation costs. They separate weak and strong zones of the field extent influence upon the cultivation costs. The length bigger than 150 to 250 m and the width exceeding 30 to 70 m are typical for properly formed fields that allow to obtain low cultivation costs. Such parameters yield the area bigger than 1 to 2 ha. Therefore, the quoted parameters can be established as the limit values defining range of length, width and area of cultivated fields.

The zones for the correct field length, area and width usually coincide with the occurrence of horizontal asymptotes and cover wide ranges within which cultivation costs remain low and hardly vary. On the contrary, the zones of strong influence of field extent upon its costs, occurring together with vertical asymptotes, are rather narrow but the changes in the cultivation costs taken within them are significant. Fields manifesting incorrect field extent are met rarely, since the farmers try to adapt the field extent to the methods of their cultivation. Therefore, they may occur massively in places where the cultivation methods are undergoing a drastic change of the cultivation style, i.e. while replacing horses with tractors. Such a situation is presently typical for many small villages in the South-East Poland.

Field area is the major field extent characteristic which on the one hand greatly shapes the production profitability, and conditions determination of other field extent parameters such as width, or length on the other. The proper field area, in the studied circumstances of low- and average-power tractors employed, shall be larger than about 1 to 2 ha. An increase in the field area by values not covered by the range is usually ineffective with regard to significant reduction of cultivation costs.

Unfavourable influence of the field length on the field cultivation costs is the most pronounced for fields which are too short, and do not exceed 100–150 m. Reducing the field length to values smaller than 100 m results in a rapid increase in the cultivating costs and damping profitability of their agricultural planning. The phenomenon is confirmed practically since 70 m wide fields are very few.

Each field area corresponds to a wide range of proper length for which decreasing cultivation costs related to the length change are insignificant. The lower limit of such a range is twice as small as the upper one; the maximal reduction of income for fields of length from within the range in normal circumstances does not exceed 0.5 cereal unit per ha. Big span of the range facilitates considerable freedom of choice while designing and realising the assumptions of the spatial rearrangements on the villages. The remark concerns both designing road networks and seeking conformance between the land layout and natural conditions.

Fields that are excessively long can also contribute to unrequired rise in the cultivation costs, especially in case of fields of areas up to 1 to 2 ha., which means the fields are at the same time too narrow and oversized in length. At such fields particular attention shall be paid to keeping as close as possible to the upper limit of the correct field length range. For fields larger than 1 to 2 ha. relatively low level of cultivation costs can be maintained if the field elongation is kept to 1:10 at the maximum. The respective width exceeds 30 to 50 m and therefore can be treated as the correct ones.

The width of a field is usually a simple consequence of its area and length, which happen to be the major parameters required to design rural land arrangement.

The field area is limited by the size of the farm, while its length depends on the road network, namely upon the distance between two neighbouring roads. Despite it, the field width shall not be neglected for the sole goal of helping in designing and assessing field extents. The considerations have lead to conclusion that correct field width shall be lager than 30 to 70 m. It means, that cultivation costs at fields with width smaller than 30 m are high and can be reduced by improving field extent parameters. Additionally, it should observed, that in the farmyards extending the fields width over 70 to 100 m is ineffective with respect to reducing cultivation costs.

While assessing a field extent mainly the field length and width shall be taken into account. If the length of the field in question, is larger than 150 to 250 m, and the width exceeds 30 to 70 m, its field extent can be considered correct and borne cultivation costs shall be higher than the minimal ones by mere 1 to 3 cereal units per ha, i.e. 2. to 5 % of the agricultural production.

In case of incorrect field length or width, in other words when the field is too short or too narrow, cultivation costs are high and can be still lowered by improving the parameters of the field extent. Since the influence of width and length upon cultivation costs is not interrelated, the detrimental effect of one cannot be balanced with the other. Improvement of the field extent parameters will be then attainable only then when the incorrectly defined parameter is changed.

Let us consider the following example: a 400 m long field of 10 m width is elongated to the unrequired level. Shortening the field by half will reduce field elongation, but will not influence its cultivation costs positively. Such a field extent can be improved only by increasing its width.

The dependence upon the field area affects the cultivation costs in a bit different manner: both length and width of the field can influence the results. Consequently, the same value of width or length can be assessed differently while representing different areas. The 400 m long field is properly formed with the area of the field equal to few ha. The same length can classify the field as badly formed if the respective area is smaller than 0.5 ha – it will be excessively elongated and its width is definitely too small.

Fields of areas bigger than from 1 to 2 ha can be usually designed with correct width and length. Such possibility cannot be registered for fields of areas smaller than 0.5 ha, i.e.

encompassing areas that do not fall into the range of proper field area. Any means taken to improve the field extent (by reshaping the field) and lower the costs will be only partially effective. Length for such fields shall vary within the range of correct values for a given area.

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