Effect of potato cultivation technology on the yield size and structure

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Abstract: Effect of potato cultivation technology on the yield size and structure. There are presented results of field experiment aimed at determination of potato response to soil compaction caused by tractor wheel passage. The three experimental variants were compared: no-traffic, traditional traffic system and traffic paths system. The carried out investigations showed that agricultural outfit passages executed during plant protection operations caused a decrease in tuber yield in the ridges next to passages. On the plots with traditional cultivation it amounted to over 13% in relation to the rows on no-traffic object. On the plots with passages a bigger share of tubers of diameter lower than 35 mm was found, while on the traffic paths object in the rows next to passage tracks the yield was higher by over 27%.

Key words: potato, traffic paths, tuber yield.

INTRODUCTION

The reasons for excessive soil compaction in field operations of various technological processes are quite well known. Besides the natural factors (impact of climatic elements) of rather small effects, it is mainly caused by mechanical actions (compaction by vehicle wheels) [Soane and Van Ouwerkerk 1994; Horn et al. 2000], with the interaction of many unfavourable elements, e.g. soil moisture content [Buliński and Niemczyk 2007], multiplicity of passages over the same track [Buliński and Niemczyk 2009], soil state during passages, and the like. Compaction, as the static state of soil properties, resolves itself mainly into an increase in soil density that results in a series of effects particularly unfavourable both for the plants and environment [Beylich et al. 2010; Whalley et al. 1995]. Many investigations carried out in various scientific institutions determine quite precisely the processes associated with compaction and describe its reasons. Nevertheless, as a result of soil compaction the yield drops are still found [Lipiec 2002; Lipiec et al. 2003], and the phenomena characteristic for soil environment degradation are created [Soane and Van Ouwerkerk 1994, 1995]; it means that this problem is not only present but becomes more and more significant in the light of decreasing farming areas and increasing population.

Although potato is regarded as the plant less sensible to soil quality, its proper development calls for careful cultivation and appropriate loosening of the arable layer [Starczewski et al. 1984]. Since the light and very light soils predominate in total ploughland areas, the potatoes are cultivated over entire Poland. There is also a trend towards specialization of
farms in potato production for industrial utilization, with an increase in the average plantation area to 50–80 ha.

The potato is an agricultural plant protected most intensively; its cultivation involves a large number of operations performed during vegetation period, when tractor wheels compact the sides and bottom of the ridge. This disadvantageously affects potato development and yield as well as soil properties [Fotyma 1972]. On stronger soils the substantial lumping occurs as a result of ridge compacting; this calls for more intense operation of the sifting conveyors in diggers and combines, that may lead to tuber damage during harvest [Wolf 2000]. The excessive compaction may be prevented by application of tractors with wider tires [Brunotte and Sommer 1993]; however, such tractors – similarly to modern potato harvesting and cultivating machines – call for the wider row spacing [Wróbel 2001]. In many farms the row spacing of 62.5 or 67.5 cm is used with respect to applied machinery, although more and more often the spacing of 75 cm is used.

The application of large and efficient machines in potato cultivation is possible due to introduction of traffic paths; this enables also to reduce the negative effects of machine wheels on the plant development conditions. The traffic paths reduce the risk of plant damage due to bigger space for the wheels of vehicles [Helmke et al. 1994] and lead to quality improvement of fertilizing and plant protection operations; it also enables to reduce the field area covered by the wheel tracks [Buliński and Niemczyk 2005]. The carried out investigations showed that application of traffic paths in potato cultivation led to an increase in the share of large tubers and commercial yield in ridges next to paths, when compared to the ridges situated next to outfit wheel tracks in standard cultivation [Helmke et al. 1994; Helmke 1995; Peters 1995; Wolf 2000].

The carried out investigations aimed at assessment of potato yielding in traffic path technology in comparison with traditional technology (passages in typical inter-rows) and with no-traffic field.

MATERIAL AND METHODS

The investigations were carried out on potato plantation of Irga species. The experiment was set up on podzol soil of: valuation class V, weak rye complex of pH 4.09, phosphorus content 11.2 mg, potassium content 7.5 mg, magnesium content 2.5 mg (per 100 g of soil). The experiment was set up by the method of long plots of length 25 m, where potatoes were planted in row spacing of 67.5 cm and along-the-row spacing of 29 cm.

The three experimental objects were marked out:

I – object with compact plants (no-traffic during vegetation period),
II – object with traffic paths designed for passages during vegetation period,
III – traditional cultivation object – passages in typical inter-rows.

In each object there were marked out 5 plots of length 1 m, covering 4 rows. The experimental layout is presented in Figure 1.

The object “Compact plants” was free from tractor outfit passages during vegetation period. In the object “Paths” planting of one potato row within tractor wheel track was abandoned. The paths were 135 cm wide. In the object “Traditional
“cultivation” the tractor wheels moved on the furrow bottom in the middle of inter-row of 67.5 cm. The plot external rows were designated with numbers 1, 4, the internal rows with numbers 2, 3. The view of field in the places of outfit passages in the compared technologies is presented in Figure 2. During plant vegetation period, on the objects with paths and with traditional cultivation there were executed 4 passages each of plant protection outfit tractor C-330 + sprayer 400 l).
The potatoes were collected separately from each row on particular plots, and the yield size per 1 row was determined; the material was divided into 3 fractions according to tuber diameter: up to 35 mm, 45–35 mm and above 45 mm.

On all objects the forecrop for potato was winter triticale and preparatory tillage operations were identical. Since all plots were situated within the same production field, one can assumed that climatic conditions (temperature, precipitation, solarization), as one of yield-creating factors, were the same on all objects. Major part of vegetation season was abound with rain. The excess of precipitation delayed the planting date. In May the amount of precipitation (141.7 mm) was almost threefold higher than the average of 30 years, in June the average precipitation (156.4 mm) was twice higher than that of previous years. After July of precipitation close to a many years’ average, in August and September a very high precipitation occurred. The total precipitation during potato vegetation period was very high and amounted to 552.2 mm.

Temperature distribution during vegetation period was similar to monthly averages of previous years. At the beginning of June the potatoes had the convenient development conditions in respect to temperature (on the average 18.9°C); it can be regarded as the optimal level from the viewpoint of plant requirements [Jasińska and Kotecki 1999].

RESULTS OF INVESTIGATIONS

Considering the potato growth and yielding conditions in particular cultivation systems one can find that the area for particular plants in the object with paths amounted to 2936.2 cm². On the compact plant object with traditional cultivation, at the row spacing of 67.5 cm and planting density 29 cm, the area per single plant amounted to 1957.5 cm², i.e. less by over 33%. The differences in area for particular plants were reflected in the average yield size. The highest tuber yield (11.19 kg) was obtained on the object with traffic paths; it was higher by 13% in relation to compact plant object and by 30.7% in relation to traditional cultivation object.

The tuber yield from plots of particular objects reflected the tuber yield per 1 m of particular rows. The average tuber yield per 1 m on the traffic path object amounted to 2.73 kg/m and was higher by over 10% than that of compact plant object (2.47 kg/m) and by 27% than that on the traditional cultivation object (2.14 kg/m). At the same time it was found that the tuber yield from the compact plant plots was more uniform (Fig. 3) than on the remaining objects and varied from 2.4 to 2.58 kg/m (on the average 2.48 kg/m).

On the object with paths the tuber yield varied respectively from 2.72 to 2.92 kg/m (on the average 2.8 kg/m), while on the traditional cultivation object from 1.96 to 2.32 kg/m (on the average 2.14 kg/m). These differences can be explained with lower soil compaction and plant damage during passages, and also with the bigger area for plants development. The yield on the traffic path object was by 10% higher than on the compact plant object, although on the latter object no passages were performed.

The tuber yield per 1 m of row is connected with amount of tubers under each plant. The highest yield under the single plant (Fig. 4) was found on the object with
paths; it averaged to about 932 g and was higher by almost 13% in relation to compact plant object, and by almost 34% in relation to traditional cultivation object.

The statistical analysis of tuber yield under the single plant was carried out by Fisher’s Multiple Range Test based on least significant differences (LSD); it showed the significance of differences between investigated objects at confidence level 95% (Tab. 1).

The yield from under the single plant is connected with number of tubers and their mass. The average number of tubers from under the single plant (Fig. 5) on the investigated plots was uniform and included in the range 12.9–14.4. The highest number of tubers was found on the object with paths, while the least number on traditional cultivation object, where it averaged to 12.9 tubers under the single plant. Although some trend may be found in the results of investigations that pointed out at most favourable conditions on the object with paths, but analysis of all measurement results showed no statistically significant differences between the objects.
The least average mass of tuber (Fig. 6) was found on the object with traditional cultivation (54.78 g), while on the objects with compact plants and the object with paths it amounted to 63.45 and 65.82 g, respectively.

The analysis of all measurement results was carried out by Tukey’s method of multiple comparison tests; at significance level $\alpha = 0.05$ it showed the significant difference in average tuber mass for the object with traditional cultivation when compared to compact plant object and traffic path object (Fig. 7). These values for the compact plant object and the path object did not differ significantly.

The division of harvested yield into fractions showed that majority of tubers on all objects had diameter bigger than 45 mm, while the percent share of tuber with diameter above 45 mm was lowest on the object with traditional cultivation. On the compact plant plots the commercial yield (tubers > 35 mm) made over 92% of all tuber mass harvested from 1 m of row, while on the traffic paths plots it amounted to almost 91%, and on the traditional cultivation plots 88.5%. The biggest share of smallest tuber fractions was found in the rows with traditional cultivation, where the plants were subjected to mechanical damage during

### TABLE 1. Significance test of differences in tuber yield under single plant for particular cultivation systems

<table>
<thead>
<tr>
<th>O.n.</th>
<th>Factor</th>
<th>Mean</th>
<th>Contrast</th>
<th>Difference</th>
<th>Boundary value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compact plants</td>
<td>824.9</td>
<td>Compact plants – traditional cultivation</td>
<td>128.3*</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Paths</td>
<td>932.1</td>
<td>Paths – traditional cultivation</td>
<td>235.725*</td>
<td>61.9456</td>
</tr>
<tr>
<td>3</td>
<td>Traditional cultivation</td>
<td>696.5</td>
<td>Compact plants – paths</td>
<td>-107.425*</td>
<td></td>
</tr>
</tbody>
</table>

* – difference statistically significant

FIGURE 5. Average number of tubers from under single plant on particular objects
FIGURE 6. Average mass of tuber (g) on particular objects

FIGURE 7. Statistical assessment of average tuber mass on particular objects

FIGURE 8. Structure of yield mass in particular cultivation systems
passages, and the sides of ridges to compaction. The percent mass distribution is presented in Figure 8.

It was found in German investigations [Helmke et al. 1994; Helmke 1995] that on the object with compact plants and the object with paths, the fraction share of tubers < 35 mm amounted to 5%, while in the rows situated next to passage tracks in traditional cultivation this share increased to 8%.

SUMMARY

Cultivation of potato is connected with the intense chemical plant protection and the resulted numerous passages of tractor outfits, that may lead to mechanical damage of tubers. Application of traffic paths in potato cultivation should greatly reduce this adverse phenomenon.

The carried out investigations proved that agricultural outfit traffic within the plant protection operations caused a decrease in tuber yield in the rows situated next to passages. On the plots with traditional cultivation it amounted to over 13% in relation to the rows on the no-traffic object (compact plants). On the plots with passages the biggest share of tubers of diameter below 35 mm was found, while on the object with paths the yield in rows next to passage tracks was higher by over 27%.

The results of investigations pointed out that potato yield size was affected by the following factors: distance between tractor wheel passages and the plant row, and the area designed for single potato plant.

It was found that number of tubers and yield under the single plant and average tuber mass on the object with paths were higher than on the objects with compact plant and with traditional cultivation.

The yield of tubers on the object with paths was significantly higher when compared to traditional cultivation.

The important advantage of traffic path application in potato cultivation may be the more advantageous structure of yield size. In the rows situated next to paths there was found the higher share of commercial yield when compared to the traditional cultivation object.

REFERENCES


Streszczenie: Wpływ technologii uprawy ziemniaków na wysokość i strukturę plonu. W pracy przedstawiono wyniki badań polowych ukazujących reakcję ziemniaków na sposób przejazdów agregatów po polu w okresie wegetacji. Porównano trzy warianty doświadczenia – bez przejazdów, z przejazdami systemem tradycyjnym i z przejazdami po ścieżkach. Wyniki badań wykazały, że najkorzystniejsze warunki rozwoju roślin stwarzały obiekty ze ścieżkami, gdzie w porównaniu z pozostałymi wariantami uzyskano najwyższy średni plon bulw z jednego metra rzędu poletek; najwyższą średnią masę bulw oraz wysoki udział plonu handlowego (bulwy > 35 mm) w strukturze masy plonu.

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