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The effect of Minituber Weight on their Field Performance under a Northern European environment

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Abstract. Weight of potato minitubers as well cultivar affects field performance of minitubers. The aim of this study was to compare minitubers of four weight classes (MtC) (3 to 4.99 g, 5 to 9.99 g, 10 to 19.99 g, and > 20 g) with respect to their field performance. Three year experiments were conducted at AREI, Latvia (57°19′ N, 25°20′ E) between 2014 and 2016. Cultivars 'Monta', 'Prelma' and 'Mandaga' were used. A significant relationship between the number of stems and the number of progeny tubers per plant was detected and the number of stems explained 74% of variation in progeny tuber number. Multiplication rate, expressed as the number of progeny tubers > 25 mm per planted minituber, was in range from 4.2 to 13.1 tubers and was significantly affected by the cultivar and MtC. Cultivar and MtC had significant effect on the number of tubers and tuber yield per m^2. The number of progeny tubers and yield increased with increases for MtC. The highest number of progeny tubers (size > 25 mm) per m^2 were obtained from minitubers > 20 g of 'Prelma' (93.4), but the highest yield was from minitubers > 20 g of 'Mandaga' (4.92 kg m^{-2}). The effect of MtC was more pronounced on number of tubers than on tuber yield. Cultivar and MtC determined mean size (diameter (μ)) of progeny tubers. Mean size increased as MtC decreased. MtC had a significant effect on standard deviation (σ) only for 'Prelma'. When σ was recalculated to coefficient of variation (*CV*), no significant effect of MtC remained.

Key words: multiplication rate, seed potato, tuber yield, tuber size distribution.

INTRODUCTION

Nowadays seed potato (*Solanum tuberosum* L.) programmes worldwide include production of small tubers called minitubers that are grown from *in vitro* derived potato plantlets (Struik, 2007). That is the initial stage of seed potato production performed under protected environments. Depending on production technology, minitubers differ in their size or weight. The size of planted minitubers can significantly influence their performance in the field (Struik & Lommen, 1999; Barry et al., 2001). Therefore, it is important to determine the minimal feasible minituber weight to have acceptable field performance when further multiplied in the field under particular conditions.

Potato yield is determined by multiple factors: the number of plants per unit area, the number of tubers produced by one plant and by the average weight of progeny tubers (Struik & Lommen, 1999).

The number of tubers per plant is affected by number of stems per plant (Knowles & Knowles, 2006) which in turn affects stem density per unit area. Bigger seed tubers produce more stems (Wurr et al., 2001) and it leads to more progeny tubers per plant (Knowles & Knowles, 2006; Bussan et al., 2007). The association between heavier tubers and larger number of stems has been observed on minitubers as well (Ozkaynak & Samanci, 2006; Dimante & Gaile, 2018).

Many authors investigating field performance of minitubers have reported significant differences between cultivars with respect to the number of tubers, yield and average weight of progeny tubers (Karafyllidis et al, 1997; Gopal et al., 2002; Radouani & Lauer, 2015; Rykaczewska, 2016; Fulladolsa et al., 2018). Cultivar can influence whether size or weight of minitubers will affect yield of progeny tubers. For example, for cultivar 'Nicola' the size of minitubers did not affect total tuber number and yield, whereas a significant effect of the size of minitubers on these variables were observed for 'Russet Burbank' (Radouani & Lauer, 2015).

For seed potato multiplication purposes it is probably more important to know multiplication rate expressed as the number of progeny tubers above a certain weight per plant than the weight produced per seed tuber (Lommen & Struik 1995). The number of progeny tubers determines replantable area or seed potential of planted minitubers. Seed potential is defined as an area (e.g. ha^{-1}) that can be replanted by seed that has been produced at unit area (e.g. ha^{-1}) planted with minitubers (Rykbost & Charlton, 2004).

Tuber size is one of the main aspects that determine yield quality (Haverkort & Verhagen, 2008). The size of marketable tubers depends on the intended use. As marketable yield is always lower than the total yield, mean tuber size and low variation in this parameter is very important not only in potato production for processing or table consumption, but also for seed potatoes. Low variation of tuber size is especially desirable. Thus due to the sizing requirements limiting minimum and maximum tuber size within a lot, low variation in tuber size can benefit minimizing certification expenses because the yield could be certified as one lot.

Many factors determine tuber size distribution of the yield. Most of them, such as number of stems per plant and the rate of crop growth, are difficult to manipulate. One of the most controllable factors is seed size (Struik et al., 1990).

Many approaches have been used in the previous studies to show tuber size distribution. Probably the most common approach is when the yield (or tuber number) of a particular grade of tubers is expressed as percentage (Georgakis et al., 1997; Fulladolsa et al., 2018) or proportion to the total yield (Bussan et al., 2007; Oliveira et al., 2017). Blauer et al. (2013) applied polygonal plots for graded yield and compared the effect of treatments on tuber size distribution. The approach developed by Travis (1987) is considered to be a very straightforward model for comparison of different field experiments. The method allows to compare results and is especially useful when different units or different size grades of the yield have been used (Wurr et al., 1993). The model of Travis (1987) allows calculation of mean size (μ) and standard deviation (σ) measuring the spread of yield across the size grades.

Little published data exists on productivity of plants from minitubers in the Northern Europe and particularly of Baltic States. Minitubers are planted relatively late (in the second part of May) in the region and growing season is relatively short. Ware potato growing habits in Baltics limit seed potato production because heavy virus pressure occurs almost every growing season. Good field performance of minitubers can favour decreasing the field generations needed for the seed multiplication and thus help maintain acceptable health status of seed potato. As a result, availability of the locally bred cultivars can be improved.

This study was conducted in a Northern European environment using three Latvian origin varieties differing in maturity class to investigate field performance of minitubers with focus on the impact of the weight class of minitubers.

MATERIALS AND METHODS

Experiments were conducted for three growing seasons (2014–2016) in the Priekuli Research Centre (PRC) at the Institute of Agricultural Resources and Economics, Latvia (57°19′ N, 25°20′ E). Cultivars bred in PRC ('Monta' – early, 'Prelma' – medium early and 'Mandaga' – medium late) were used in the study.

Minitubers were grown from *in vitro* plantlets in greenhouses at PRC and harvested in August on average 78 days ('Monta' and 'Prelma') to 92 days after planting ('Mandaga'). The storage period of obtained minitubers was nine months including seven months in cold storage (3 °C). Minitubers were de-sprouted two weeks before planting in the field and then pre-sprouted under diffused natural light.

Minitubers of four weight classes (MtC) 3.00 to 4.99 g, 5.00 to 9.99 g, 10.00 to 19.99 g, and > 20 g were hand planted on 15 May 2014, 19 May 2015 and 16 May 2016.

The content of organic matter in the soil was low to optimal. Availability of phosphorus and potassium in the soil was medium to high (Table 1). Fertilizers were applied to the experimental field one week before planting at the rate of 60 kg. N ha^{-1}, 55 kg P_2O_5 ha^{-1} and 90kg K_2O ha^{-1}. Deep tillage (25–26 cm) was performed after the broadcasting of the fertilizers. Plant protection measures were aligned with the integrated pest management practice.

Table 1. Characteristics of the soil at the study site, 2014–2016

Indices	2014	2015	2016
Soil	Sod-podzolic loamy sand		
Soil pH KCl	4.5	5.0	5.3
Organic matter content,%	2.1	2.1	1.8
K_2O mg kg^{-1}	189	142	143
P_2O_5 mg kg^{-1}	164	150	120
Pre-crop	winter cereals		

A split-plot design was used for the study. Weight classes of minitubers were randomized as sub-plots within the cultivars as main plots. Three replications were applied in 2014 and four replications in 2015 and 2016. The distance between rows was 0.7 m. In-row spacing between planted minitubers was 0.2 m. In each sub-plot 48 minitubers (12 tubers × 4 rows) were planted. Plants from two outer rows as well as one plant at the beginning and one at the end of each inner row were excluded from the yield assessment to minimize the effects of plant competition between plots with different treatments and to exclude the border effect.

The overall meteorological conditions at the location of the conducted experiments are shown in Table 2.

Table 2. Meteorological conditions in Priekuli, long term average and 2014–2016

Period	Average air temperature, °C				Sum of precipitation, mm			
	LTA*	2014	2015	2016	LTA*	2014	2015	2016
Last 10 days of May	13.2	15.5	11.6	16.6	21.1	36.5	24.3	0.5
June	14.9	13.5	14.3	16.4	81.2	108.3	39.4	144.5
July	17.5	19.5	15.9	17.9	86.0	76.5	91.5	109.5
First 10 days of August	17.7	21.8	19.1	16.7	24.5	30.2	16	54.5
Last 20 days of August	15.7	14.4	17.1	16.1	57.1	128	8.1	121.3

*LTA is long term (1981–2010) average.

In 2015 and 2016 air temperature of the end of May exceeded the long term average (LTA) thus promoting emergence of the plants. After the warm beginning of the season, cooler weather followed in the last 20 days of June 2014 (3.1 °C below the LTA). In the same period of 2016 the air temperature was close to the norm. The precipitation was unevenly distributed across the growing season in these two years. In the last 20 days of June 2014 and the first 10 days of July the sum of the precipitation reached 169 to 222% of the average from long term data. In the last 20 days of July 2014 less than average rain was recorded (43 to51%). Precipitation in August 2014 again exceeded long term average data and prolonged rain periods burdened the harvesting. In 2016 precipitation exceed the long term data in all periods of the growing season except the last 10 days of July. Heavy rain fell (58 mm) over 24 hours at the end of June 2016. Despite of the optimal air temperature, canopy closure was slowed down because of the water logging in the field. However, further conditions favoured yield formation.

The situation in 2015 was slightly different. Plant emergence from minitubers was considerably delayed as a result of low air temperatures at the end of May and dry conditions (7 mm of precipitation in the first 20 days of June) later in first part of June. In the last 10 days of June 2015 the amount of precipitation increased, thus favouring canopy development of the plants and weather conditions were favourable for yield formation.

In 2014 cultivars 'Monta' and 'Prelma' were harvested on August 14 and 15 (91 and 92 days after planting), cultivar 'Mandaga' was harvested on September 4 (112 days after planting). Harvest time was influenced by the meteorological conditions as described above. In 2015 and 2016 'Monta' and 'Prelma' were harvested in the first days of August and the length of vegetation season for these cultivars was 78 to 80 days, whereas vegetation season for 'Mandaga' was 94 to 98 days.

Tubers from each individual plot were harvested by hand and then graded in the following size grades (TSG): < 25 mm, 25–35 mm, 35–45 mm, 45–55 mm, > 55 mm by passing tubers through a square mesh hand grader. Yield and the number of tubers per size grade were determined.

Multiplication rate was calculated as the number of tubers > 25 mm (the minimal size of potato seed according to UNECE standard S-1 seed potatoes) derived from each planted minituber.

Analysis of variance (ANOVA) using R studio running against R version 3.2.5 was applied to determine the effects of two main factors – cultivar and MtC. Differences between the treatments were compared using Tukey's HSD test (α = 0.05).

A linear regression was performed to relate progeny tuber number to number of above ground stems as well as to relate mean weight of progeny tuber to total tuber number per m^2.

Data on tuber numbers and total weight per size grade were used for the determination of tuber size distribution according to Travis (1987).

To uncover the variance and mean of the grouped data the formulas (1) and (2) were used:

The mean was calculated as

$$\bar{\mu} = \sum \frac{f\mu}{n} \quad (1)$$

Variance, denoted by σ was defined as

$$\sigma = \sqrt{\frac{\sum f(\mu - \bar{\mu})^2}{n}} \quad (2)$$

Where σ is standard deviation, $\bar{\mu}$ is the mean, μ stands for each data value in turn, and f is the frequency with which data value μ, occurs, n is data-set extent.

The means and variances were calculated for individual plots and then obtained values were subjected to analysis of variance (ANOVA) to verify if variety and MtC have significant impact on mean and variance of progeny tuber size.

RESULTS AND DISCUSSION

Relation between stem number and progeny tuber number

In our previous research, significantly more above ground stems were produced by the heavier minitubers (Dimante & Gaile, 2018). Linear regression analysis revealed a highly significant ($P < 0.001$) relationship between the number of stems and the number of progeny tubers per plant (Fig. 1).

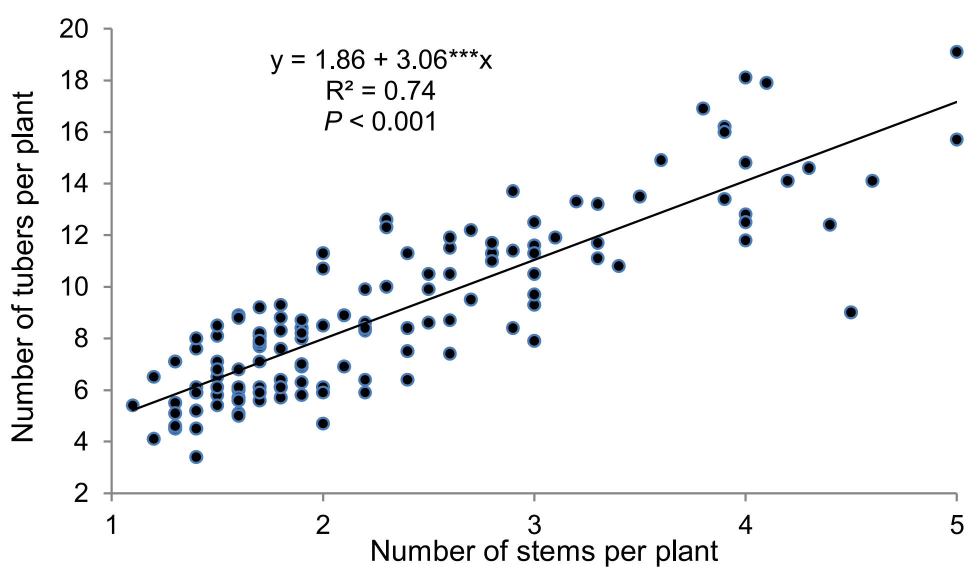

Figure 1. Relationship between number of tubers and number of stems per plant.
*** Significant at 0.001 probability level by *t*-Test.

The number of progeny tubers per plant increased by 3.06 units as a result of an increase in stem number by 1 unit per plant. The obtained regression trend for minitubers is in line with the data reported previously by Knowles & Knowles (2006), Bussan et al. (2007) and Goeser et al. (2012) which found that increases in stem number significantly increased number of tubers per plant for conventional seed potato. Furthemore, in our research, number of stems explained 74% of variation in tuber number in comparison with 55% obtained by Bussan et al. (2007).

Multiplication rate

Multiplication rate-expressed as the number of progeny tubers > 25 mm obtained from one planted minituber was affected by both the cultivars ($P < 0.001$) and MtC ($P < 0.001$). Cultivar by MtC interaction was significant too ($P < 0.001$). For all cultivars, the largest MtC produced significantly higher number of seed tubers (> 25 mm) per plant. No significant differences were found between the two smallest MtC (Fig. 2). However, the pattern of the increase of multiplication rate with increases of MtC was different for the studied cultivars.

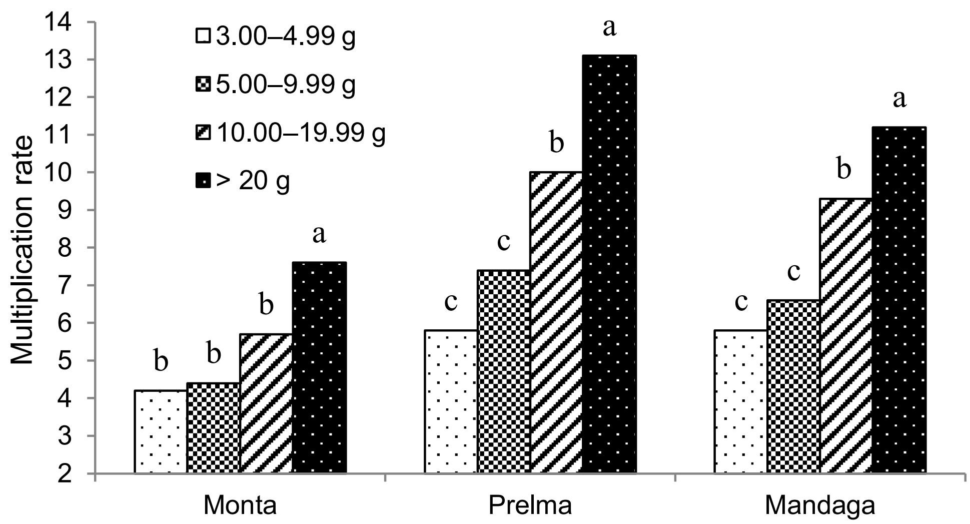

Figure 2. Number of progeny tubers of size > 25 mm obtained from one planted minituber (multiplication rate) depending on weight class of minituber.

Different letters indicate significant differences ($P < 0.05$) between MtC within cultivar by Tukey's test ($P < 0.05$).

The increase of multiplication rate for cultivar 'Monta' was the least pronounced. The lightest MtC produced 4.2 tubers of size > 25 mm, while 7.6 seed size tubers per plant were obtained from MtC > 20 g. Only the latter MtC significantly ($P < 0.001$) differed from other classes.

Minitubers from the lightest class of cultivars 'Prelma' and 'Mandaga' had the same multiplication rate: 5.8 tubers of size > 25 mm. Multiplication rate of 'Prelma' had a tendency to have relatively more pronounced increase compared with 'Mandaga'. The gap between MtC continued to increase until the heaviest MtC. This resulted in the highest multiplication rate among all treatments – 13.1 progeny tubers were produced per one minituber > 20 g from cultivar 'Prelma'. 'Mandaga' had significant increase of multiplication rate with increase of MtC as well, however, the magnitude of increase slightly declined between the two heaviest MtC.

Dimante & Gaile (2018) observed significantly lower emergence rate of 'Monta' in comparison with 'Prelma' and 'Mandaga'. Averaged across the years and MtC, emergence rate of 'Monta' was 87%. However, the low emergence rate of this cultivar only partially explains the low multiplication rate. When we recalculated multiplication rate to the number of progeny tubers > 25 mm per emerged tuber, it still remained relatively low, ranging from 5.4 to 8.3 progeny tubers per emerged plant. However, the approach when multiplication rates have been calculated as progeny tubers per emerged tuber demonstrates the potential of the cultivar.

The results obtained in our research agree with those published by the other authors (Barry et al., 2001; Gopal et al., 2002; Ozkaynak & Samanci, 2006; Wrobel, 2015). Moreover, as we used only progeny tubers of size > 25 mm for calculation of the multiplication rate, we can assume that this parameter is even higher, especially minitubers > 20 g of the cultivar 'Prelma' had an exceptionally high multiplication rate.

The number of progeny tubers and their yield

The number of progeny tubers and tuber yield per m^2 was significantly affected by the cultivar ($P < 0.001$) and MtC ($P < 0.001$). The interaction between the main factors was significant for number of progeny tubers ($P < 0.001$). Yield data of progeny tubers (all tubers and those of size above 25 mm) did not interact significantly between the main factors ($P = 0.542$ and $P = 0.545$ respectively). The data in Table 3 shows an increase of all variables with the increases of MtC and this trend is generally consistent with findings of other authors (Struik & Lommen, 1999; Barry et al., 2001; Ozkaynak & Samanci, 2006; Radouani & Lauer, 2015).

Table 3. Number of progeny tubers and tuber yield produced by minitubers of four weight classes (MtC), 2014–2016

Variable	Weight class of minitubers, g	Cultivar			*Mean of*
		Monta	Prelma	Mandaga	*MtC*
Number of progeny tubers per m^2	3.00–4.99	$34.10^{b\ B}$	$46.80^{c\ A}$	$45.10^{c\ A}$	42.00^{c}
	5.00–9.99	$35.70^{b\ B}$	$59.50^{c\ A}$	$51.40^{c\ A}$	48.90^{c}
	10.00–19.99	$47.30^{ab\ B}$	$82.10^{b\ A}$	$73.80^{b\ A}$	67.70^{b}
	> 20.00	$62.30^{a\ B}$	$109.50^{a\ A}$	$92.40^{a\ A}$	88.10^{a}
Tuber yield, kg m^{-2}	3.00–4.99	$2.08^{b\ C}$	$2.90^{c\ B}$	$3.82^{bc\ A}$	2.930^{b}
	5.00–9.99	$2.16^{b\ B}$	$3.54^{bc\ A}$	$3.75^{c\ A}$	3.15^{b}
	10.00–19.99	$2.80^{ab\ B}$	$4.02^{ab\ A}$	$4.73^{ab\ A}$	3.85^{a}
	> 20.00	$3.16^{a\ B}$	$4.78^{a\ A}$	$4.98^{a\ A}$	4.30^{a}
Number of progeny tubers of size > 25 mm per m^2	3.00– 4.99	$30.20^{b\ B}$	$41.10^{c\ A}$	$41.20^{c\ A}$	37.50^{c}
	5.00– 9.99	$31.20^{b\ B}$	$53.00^{c\ A}$	$46.70^{c\ A}$	43.70^{c}
	10.00–19.99	$40.50^{b\ B}$	$71.30^{b\ A}$	$66.50^{b\ A}$	59.40^{b}
	> 20.00	$54.30^{a\ B}$	$93.40^{a\ A}$	$80.00^{a\ A}$	75.90^{a}
Tuber of size > 25 mm yield, kg m^{-2}	3.00–4.99	$2.05^{b\ C}$	$2.85^{c\ B}$	$3.79^{bc\ A}$	2.90^{b}
	5.00–9.99	$2.12^{b\ B}$	$3.49^{bc\ A}$	$3.71^{c\ A}$	3.11^{b}
	10.00–19.99	$2.76^{ab\ B}$	$3.95^{ab\ A}$	$4.70^{ab\ A}$	3.80^{a}
	> 20.00	$3.11^{a\ B}$	$4.69^{a\ A}$	$4.92^{a\ A}$	4.24^{a}

Means within variable in the same column followed by different lowercase letter and means in the same row followed by different capital letter are significantly different by Tukey's test ($P < 0.05$).

However, in some studies the results are not that straightforward. For example Karafyllidis et al. (1997) in a study conducted in Greece with four sizes of minitubers concluded that only minitubers of size below 10 mm were unsuitable for field planting as they produced significantly less tubers and yield than those which size was between 10 and 25 mm. Additionally Radouani & Lauer (2015) found even decrease in number of progeny tubers and insignificant increase of the yield as a result of increase in planted minituber weight for the cultivar ‘Nicola’.

Significant differences between the two smallest MtC (3.00–4.99 g and 5.00–9.99 g) according the number of progeny tubers and tuber yield were not observed in the present study for all cultivars. The highest number of progeny tubers per m^2 were produced by the cultivar ’Prelma’. Although minitubers of cultivar ’Mandaga’ produced less tubers, the obtained yield was higher than that of ’Prelma’, though insignificantly.

The most pronounced relative increase of number of progeny tubers and tuber yield per m^2 with increase of MtC was observed for cultivar ’Prelma’. Thus from MtC > 20.00 g we obtained 2.3 times more progeny tubers and 1.6 times higher yield (kg m^{-2}) than from MtC 3.00–4.99 g. In comparison, the number of progeny tubers for cultivar ‘Monta increased only 1.8 times, which was the smallest increase between cultivars, whereas ‘Mandaga’ had the smallest increase of tuber yield (1.3 times).

In general the obtained results show more pronounced effect of MtC on number of progeny tubers than on tuber yield. This can be explained by the decrease of mean weight of progeny tubers in plots with higher number of progeny tubers (Knowles & Knowles, 2006; Bussan et al., 2007; Blauer et al., 2013). In our study the relationship between the number of tubers per m^2 and mean weight of tubers (g) was significant ($R^2 = 0.31$; $P < 0.001$). In a study by Rykaczewska (2016), a decrease in the mean weight of tubers resulted in insignificant differences of progeny tuber yield between sizes of minitubers, while in our study we still observed a significant effect of MtC on progeny tuber yield (Table 3).

Tuber yield obtained from the smallest MtC of ‘Mandaga’ exceeded the yield obtained from the biggest MtC of ‘Monta’. Low tuber numbers and yield of cultivar ‘Monta’ can be a result of low emergence rate which was on average 87% over all MtC (Dimante & Gaile, 2018).

Despite the short growing season, number of progeny tubers per m^2 and tuber yield per m^2 in the present research was similar to those in other studies with longer growing seasons and even exceeded some of the previously published data. Thus Radouani & Lauer (2015) obtained 44–63 tubers and the yield was 1.63–5.8 kg m^{-2} under 120 days of vegetation season in Morocco. Besides, relatively big minitubers in the range of 15–60 g were used in the study. Rykaczewska (2016) investigated field performance of conventionally grown minitubers of size 15–22 g under 144–147 days of vegetation season in Poland. In the study, 68–71 progeny tubers were obtained per m^2 and yield was 2.90 to 5.3 kg m^{-2}. In Turkey, Ozkaynak & Samanci (2006) used minitubers of three weight classes (6–8 g, 8–16 g and 16–18 g) and reported only 1.3–1.5 kg of progeny tubers per m^2 harvested 88 to 102 days after planting. The investigation conducted by Barry et al. (2001) in Ireland with an unspecified length of growing season showed 33.2–53.5 progeny tubers m^{-2}.

Results of our study suggest considerable potential to obtain high yields and numbers of progeny tubers in our region despite of the late planting and short growing season.

Progeny tuber size distribution

Progeny tuber size distribution was expressed in kilos per m^2 per each mm progeny tube size (Fig. 3).

The common pattern for all cultivars was that yield of progeny tubers from minitubers > 20 g was approximately normally distributed. As MtC decreased, a shift of the size distribution towards higher yield proportion of larger tubers was observed. Knowles & Knowles (2006) observed similar shift in tuber size distribution for plots where conventional seed potatoes produced less stems. Acquired relationship can be attributed to our results as less stems were produced by smaller minitubers.

Mean tuber size (μ) was significantly affected by the cultivar and MtC ($P < 0.001$). There was no significant interaction between the treatments ($P = 0.470$). The effect of MtC on standard deviation of tuber size (σ) was significant ($P < 0.01$) too, whereas no significant effect of the cultivar ($P = 0.188$) and no significant cultivar by MtC interaction was observed ($P = 0.340$).

The only cultivar showing a significant effect of MtC on σ ($P < 0.05$) was 'Prelma'. Smaller MtC had larger values of tuber size (μ) expressed in mm. The increase of μ values led to an increase in variability of tuber size (σ). According to Wurr et al. (1993), a positive relation between σ and μ exists. This relation was also found in the case of 'Prelma'. Wurr et al. (1993) suggested use of coefficient of variation (CV) as more stable measure of variability. Following the suggestion of Wurr et al. (1993), we recalculated variability to CV, and the effect of MtC was not more significant ($P = 0.354$). Overall, the calculated value of CV ranged between 17 and 19% across all treatments and variation of progeny tuber size did not depend on MtC. As a result, the yield obtained from every single MtC was quite uniform in terms of the tuber size. This suggests good potential for obtaining a high proportion of marketable yield.

Georgakis et al. (1997) expressed tuber size distribution as a percentage and found that the size of minitubers did not affect the size distribution of progeny tubers. For all cultivars and minituber sizes, > 50% of progeny tubers were in range of 25–50 mm. However, the proportion of undersized tubers (< 25 mm) was quite high, and depending on cultivar and planted minituber size, it ranged from 15 to 41%. These results can hardly be compared to ours as the proportion of progeny tubers smaller than 25 mm was below 15% for all treatments used in our study. In addition, the proportion of undersized progeny tubers tended to be lower in plots planted with the lightest classes of minitubers (data not shown). Fulladolsa et al. (2018) compared minitubers and conventional tubers with respect to the tuber size distribution. The obtained results on effects of seed source on progeny tuber size distribution were not convincing over years, however, the proportion of undersized and standard sized progeny tubers obtained from minitubers (i.e. smaller seed) was higher than that from conventional tubers (i.e. larger seed). These findings are not consistent with results of our research, as the proportion of larger tubers increased with decrease of MtC (i.e. seed size). Fulladolsa et al. (2018) explained that these minitubers produced significantly more culls that were discarded from the total yield.

The data on the number and yield of progeny tubers and their size distribution can help estimate the appropriate amount and size of minitubers that are necessary to obtain certain yield level of desired size of progeny tubers.

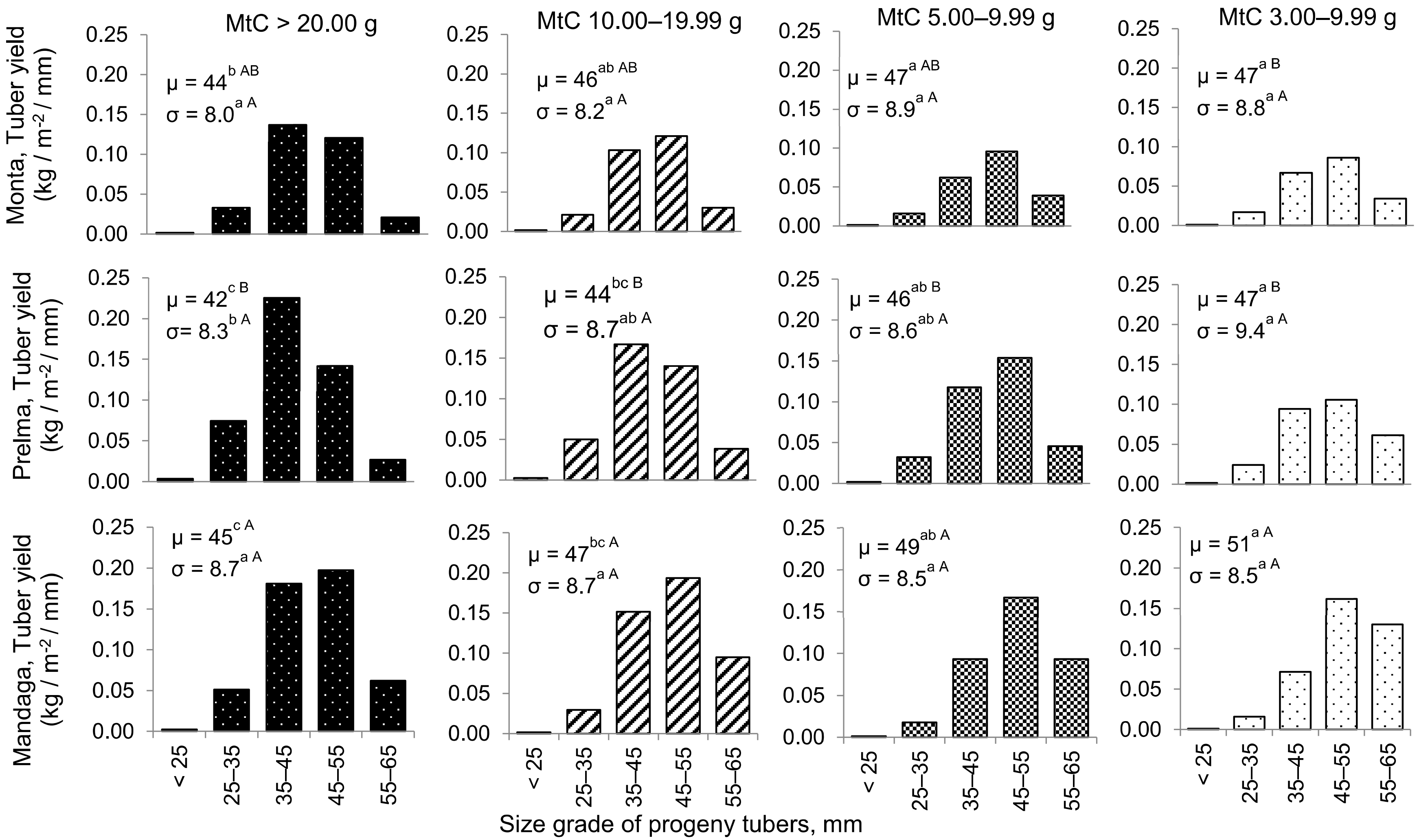

Figure 3. Progeny tuber size distribution depending on weight class of planted minituber (MtC) and cultivar.

μ – mean tuber size; σ – standard deviation of tuber size; Means within cultivar and between MtC followed by different lowercase letter and means within MtC between cultivars followed by different capital letter are significantly different by Tukey's test ($P < 0.05$).

CONCLUSIONS

The choice of cultivar and weight class of planted minituber (MtC) significantly affected field performance variables such as yield, the number of progeny tubers, multiplication rate, and tuber size distribution.

The larger was the planted minituber, the higher yield and more progeny tubers were obtained. However, the magnitude of increase in the yield and number of progeny tubers between MtC significantly depended on the cultivar. The decrease of the mean weight of progeny tubers in plots with higher number of progeny tubers resulted in more pronounced effect of MtC on number of progeny tubers than on tuber yield. The magnitude of increase of multiplication rate was also cultivar-dependent. Mean size (μ) of progeny tubers significantly increased as MtC decreased, but the standard deviation (σ) measuring the spread of yield across the grades was significantly affected by MtC only for the cultivar 'Prelma'. Furthermore, coefficient of variation as relative measure of variability was not MtC-dependent.

Results of our study suggested considerable potential for obtaining high yields and numbers of progeny tubers in our region despite of the late planting and short growing season. Relatively low variation of mean tuber size of progeny tubers within each treatment was detected and no effect of MtC was observed. These findings show potential to obtain a high proportion of marketable yield from minitubers with weight over 3 g and to grade the greatest part of the yield into one seed lot.

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