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Effect of different doses of apple pomace to the substrate on photosynthetic efficiency and yield in common buckwheat in a model experiment

*Marcin Różewicz**

Department of Cereal Crops, Institute of Soil Science and Plant Cultivation – State Research Institute,
Czartoryskich 8, 24-100 Puławy, POLAND

*corresponding author: e-mail: Marcin.Rozewicz@iung.pulawy.pl; phone +48 81 4786 818

Abstract. By-products of apple juice pressing should be used for the benefit of the environment. One way to manage them is to add them to the soil in raw or composted form as a natural fertiliser and source of organic matter. A study was therefore undertaken to test several doses of apple pomace to the substrat on photosynthetic parameters and yield of buckwheat. The experiment was conducted in a vegetation hall under controlled, automatic irrigation to 60% of the field water capacity. The model study used the cultivar Red corolla and three doses of apple pomace applied to pots in the following amounts: 0 control, 70, 140 and 210 g per pot, which corresponded to field volume: 1, 2 and 3 $t \cdot ha^{-1}$. Four photosynthetic parameters (Pn, E, Gs and Ci) were measured and the water use efficiency was determined. Chlorophyll fluorescence (Fv/Fm and PI) was also investigated. The most suitable variant for buckwheat was the using 210 g which resulted in increased photosynthesis intensity, chlorophyll fluorescence and buckwheat yield.

Keywords: buckwheat, yield, apple pomace, organic matter, photosynthesis

INTRODUCTION

The food industry generates large quantities of organic by-products that require appropriate, environmentally friendly disposal. In the case of fruit and vegetable processing, apple pomace accounts for the largest share of total waste production. Poland is one of the largest producers of apples in Europe and the third largest in the world (larger producers are China and the USA), and a significant part of this fruit is used for the production of juice and apple concentrate (https://www.tridge.com/intelligences/apple/production). The apple harvest depends on weather conditions, in particular the spring frosts, but on average, fruit-growers in Poland harvest around 4 million tonnes of apples annually, of which as much as 54% is used for the production of apple concentrate and juices. In the juice-pressing process, a by-product in the form of pomace is produced that constitutes around 25–30% of the initial mass of processed raw material. Estimating the apple harvest and the fact that more than half of it is used for juice production, approximately 0.7 M tonnes of pomace are obtained per year, which need to be utilized. The increasing amount of waste generated in fruit processing, which includes seeds, pulp residues and peel, creates a global environmental and economic problem. A small proportion of it is reused in the food industry (Kawecka, Galus, 2021; Masiarz et al., 2019; Sadowska et al., 2022, Sobczak et al., 2022; Rana et al., 2022). They can also be partially used as animal feed, but only in limited quantities, as exceeding the allowed proportion in feed results in poorer production performance (Jóźwiak et al., 2019). An additional problem in the management of apple pomace is also the fact that it still contains a significant amount of water, which promotes its rapid spoilage. It is therefore not possible to store them for long periods of time or transport them over long distances. The concentration of orchards and the specialization of orchard farms also poses a problem. Assuming an average fruit yield of 40 t per hectare of industrial orchard, up to 10 t of biohazardous waste will remain after pressing. This necessitates the search for economic and logistical, as well as ecological solutions for its utilization. It is therefore necessary to carry out research that will contribute to a better use of pomace for the benefit of the environment, entrepreneurs, and consumers.

The biggest hindrance to the use of pomace is the constant production process and the fermentation processes that take place in the pomace. To prevent fermentation, raw material needs to dried until the time of transport. One possible solution is to manage the pomace as an source of organic matter for the soil. This type of pomace management would result in benefits for society and the environment. Cooperation between juice mills and farmers, who could buy pomace, would bring benefits in the form of reduced environmental impact associated with lower fuel consumption for transport as farmers live in close vicinity to mills, as well as potentially beneficial effects on soil and crop yield. Apple pomace contains significant amounts of pectin, which binds water and can presumably effectively retain it in the soil. The pomace also has the advantage of containing valuable elements that return to the soil, but also phytochemicals that can have a positive effect on soil, biological activity and plants. The phytochemical components of apple pomace have antifungal effects against some plant pathogens (Oleszek et al., 2019; Oszust, Frąc, 2020). In addition, pectin contained in apple pomace can protect plants from absorbing harmful heavy metals and accumulating these metals in their tissues (Gholizadeh, Ziarati, 2016). The various directions of use of pomace offer the possibility of successive collection and efficient use, with its fertilizing properties to be exploited at the end, when no other use is possible. The use of pomace addition to soil can have multifaceted positive effects on both plants and soil. To date, the scientific literature on the application of apple pomace to soil is very scarce. Undertaking research on this topic will allow us and to determine the optimum dose of apple pomace that will have the most beneficial effect on plants. An attempt was therefore made to address the problem of rapid pomace management in order to prevent its fermentation in a potting model experiment. The aim of the study was to evaluate the effect of adding apple pomace on buckwheat plants. It was hypothesized that increasing the dosage of apple pomace in substrate improves the efficiency of the photosynthetic apparatus of common buckwheat plants and their yielding.

MATERIAL AND METHODS

Plant growth conditions

A three-year pot experiment was conducted from 2019 to 2021 in the vegetation hall of the Institute of Soil Science and Plant Cultivation – State Research Institute in Puławy [51°24′59″N 21°58′09″E]. Common Buckwheat (*Fagopyrum esculentum*) of the Red corolla cultivar was used in the experiment. This cultivar was developed as a result of crossbreeding between the Hruszowska cultivar and the Buryatskaya population grown under steppe conditions in the former USSR. A characteristic feature of this cultivar is the red colour of the cotyledons, perianth leaves and it produces more green mass than the mother cultivar Hruszowska. It is more resistant to adverse weather conditions and at the same time, exhibits higher tolerance to reduced genetic variation within one cultivar. The weight of one thousand seeds is approximately 26.0 g. This cultivar is characterised by high seed yield and quality, as well as resistance against diseases and lodging (Wolińska et al., 2015). An experiment was set up using Mitscherlich pots containing 7 kg of substrat in four replicates for each treatment. Soil was collected from a field where cereals constituted 100% of crop rotation. It was taken from the 0–30 cm layer of Haplic Luvisol, made of clay. The concentration of selected elements in the soil was the following: total carbon – 0.90%, organic carbon – 0.78%, total N – 0.10%, P_2O_5 – 27.7 mg·100 g^{-1}; K_2O –28.2 mg·100 g^{-1}; pH 6.08. The experimental factor was the level of apple pomace, the composition of which is shown in Table 1, mixed with the substrate before seeding. The pomace came from the Kępa juice mill. It was received fresh, just after the juice had been pressed, and then dried in a drying room for 24 hours at 40 °C with air circulation. They were then added to the soil. Four levels of factor were used:

- K – Control without the addition of pomace to the substrat,
- D1 – addition of 70 g of dry matter of pomace per pot (corresponding to a field application rate of 1 t ha^{-1}),
- D2 – 140 g dry matter/pot (2 t ha^{-1}),
- D3 – 210 g dry matter/pot (3 t ha^{-1}).

Pre-sowing macro- and micronutrient fertilisation was applied at a rate of:

- P_2O_5 – 2.52 g pot^{-1} as KH_2PO_4,
- K_2O – 2.04 g pot^{-1} as $K_2\ SO_4$,
- Mg – 0.5 g pot^{-1} in the form of $MgSO_4$,
- Fe 50 – mg pot^{-1},
- B – 5 mg pot^{-1},
- Mn – 3 mg pot^{-1},
- Cu – 3 mg pot^{-1}.

Table 1. N, C K, and P content in apple pomace from Kępa juice mill.

Specification	N	C	K	P	Water content [%]
Content [% of dry matter]	1	8	0.17	0.7	80

Nitrogen fertilisation was applied at a rate of 1.2 g of N per pot using NH_4NO_3.

Sowing was done at the optimum date for buckwheat in the first decade of May. 20 seeds were sown in each pot, leaving 10 of the strongest plants after emergence, which were maintained until harvest. Plants were watered automatically twice a day with an interval of 12 hours to 60% of the field water capacity.

Photosynthesis and chlorophyll fluorescence parameters

The photosynthesis measurements were performed with a CIRAS-2 Portable Infrared Gas Exchange Analyser Type CIRAS-2 Portable Photosynthesis System (Hitchin, Herts., UK).

The measured parameters were:

- net photosynthetic efficiency Pn (µmol CO_2 m^{-2} s^{-1}),
- effectiveness of transpiration E (mmol H_2O m^{-2} s^{-1}),
- stomatal conductance G_s (mmol H_2O m^{-2} s^{-1}),
- intracellular carbon dioxide concentration C_i (µmol m^{-2} s^{-1}).

Photosynthesis was measured at three developmental stages in four replicates on each experimental treatment. A measuring cell was placed on the top leaf with a light intensity of 1000 PAR (µmol m^{-2} s^{-1}) supplied by a light unit attached to the cuvette. The following conditions were assumed in the analyser cuvette: a constant supply of carbon dioxide equal to 370 ppm (µmol CO_2 mol^{-1} of air), humidity equal to the ambient humidity, air temperature equal to +25 °C. For each experimental plot, a measurement was taken at the centre at four randomly selected plants. In addition, the photosynthetic water use efficiency (WUE) was determined from the ratio of net photosynthetic efficiency to effectiveness of transpiration (Pn/E).

Photosynthesis was measured in three BBCH stages:

- BBCH 60 – appearance of first flowers,
- BBCH 65 – full bloom 50% open flowers,
- BBCH 71 – beginning of nut development.

During the same stages and on the same day as photosynthesis the fluorescence of chlorophyll was also measured using a PocketPEA fluorimeter (Hansatech Instruments – GB).

A clip with a closed plate was placed on selected top leaves to adapt the sample in the dark for 20 minutes causing one of the photosynthetic stages to 'go out'. The device used for the measurements is equipped with diodes with a maximum emission of 650 nm and a near-infrared filter. Readings were taken using a PocketPEA fluorimeter (Hansatech Instruments – GB). The index of maximum quantum efficiency of photosystem II (PSII) (Fv/Fm), and the photosystem II performance index (PI) was evaluated.

Determination of seed yield and yield structure

At the full nut maturity stage, when 80% of the seeds were fully ripe, irrigation disconnection was applied for seven days before the harvesting period, and then harvesting and yield calculations were made: for the pot and for one plant per pot by dividing the yield obtained per pot by the number of plants per pot. The weight of one thousand seeds was also calculated. The weight of aboveground part of the plants and their height were also measured.

Statistical analysis of the data

The analytical data obtained were the average of 4 pots from the same treatment. The years of the study were treated as repetitions because it was an experiment under greenhouse conditions. Statistical analysis of the results obtained was performed with Statistica v.13.1. using the Tukey test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Photosynthesis is the most important process in plants for their growing. Environmental conditions and possible physiological stresses to which plants are exposed, determine its intensity. As a result of our own research, the addition of pomace to the substrate was shown to have a beneficial effect on photosynthesis values in buckwheat plants. In each of the stages studied the net photosynthetic efficiency increased with increasing substrate pomace content (Table 2). Only for the first dose (D1) this difference was nonexistant compared to the control. The highest differences in net photosynthetic efficiency between the control and D3 were shown at the BBCH 60 stage, with a percentage difference of 52%. In contrast, the difference in net photosynthetic efficiency was still significantly higher at the subsequent stages, but the trend was downward. Correspondingly, at the BBCH 65 stage it was 45% and at the BBCH 71 stage it was 36%.

The effectiveness of transpiration reached the highest value in the D3 and D2 treatment at BBCH 60. In the other stages, the effectiveness of transpiration was highest with the highest pomace dose, but a significant difference between the D2 and D3 treatment was only found at BBCH 71. With respect to the control treatment (K), the difference in effectiveness of transpiration was on average 33% in the three stages. The highest difference was found at BBCH 65 and was 36%, while in the other two stages it was on average 30%.

Table 2. Plant photosynthetic parameters as a function of growth stage and amount of pomace addition to the soil (average for each stage over the three years of the study).

Treatment	Pn [μmol CO_2 m^{-2} s^{-1}]	E [mmol H_2O m^{-2} s^{-1}]	Gs [mmol H_2O m^{-2} s^{-1}]	Ci [μmol CO_2 m^{-2} s^{-1}]	WUE [μmol CO_2 mmol H_2O^{-1}]
BBCH 60 – appearance of first flowers					
K	6.2 c	1.4 b	0.178 a	206 b	4.43 b
D1	6.2 c	1.6 ab	0.179 a	214 b	3.88 c
D2	8.0 b	1.9 a	0.180 a	227 a	4.21 cb
D3	9.4 a	1.9 a	0.184 a	233 a	4.95 a
BBCH 65 – full bloom 50% open flowers					
K	6.5 c	1.3 b	0.180 a	210 c	5.0 b
D1	6.6 c	1.3 b	0.178 a	215 bc	5.1 b
D2	8.2 b	1.5 ab	0.185 a	220 b	5.5 a
D3	9.4 a	1.7 a	0.183 a	233 a	5.5 a
BBCH 71 – beginning of nut development					
K	6.6 c	1.5 c	0.200 a	212 b	4.4 ab
D1	6.6 c	1.5 c	0.209 a	217 ab	4.3 b
D2	7.2 b	1.7 b	0.213 a	210 b	4.2 b
D3	9.0 a	1.9 a	0.210 a	220 a	4.7 a

K – control, D1 – 70 g (of dry matter of pomace per pot), D2 – 140 g, D3 – 210 g

Pn – net photosynthetic efficiency; E – effectiveness of transpiration; Gs – stomatal conductance; Ci – intracellular carbon dioxide concentration, WUE – photosynthetic water use efficiency

Values in columns signed with different letters (a-c) are significantly different for each BBCH stage ($\alpha \leq 0.05$)

Stomatal conductance between plants in the different treatments was not statistically significant at any of the stages tested. However, a trend towards a slight increase in stomatal conductance with increasing pomace addition at each of the BBCH stages tested can be indicated.

The intracellular carbon dioxide concentration had the highest value in plants with the highest pomace addition into the substrate (D3) at all BBCH stages tested. Compared to the control (K), plants from D3 showed an average 9% higher intracellular carbon dioxide concentration. However, it should be noted that this difference showed a decreasing trend with subsequent stages. At BBCH 60 it was 13%, BBCH 65 – 11% and at BBCH 71 only 4%.

The water use efficiency (WUE) varied according to the BBCH stage and the addition of pomace to the substrate. However, it was always the highest at D3 treatment. At the BBCH 60 stage, plants on treatments D1 and D2 showed a lower WUE value than on treatment K. At the same time, the increased dose of pomace to the substrate on treatment D2 did not cause any statistical difference. However, a significantly higher difference was found between the K and D3 treatment, with the difference being 12% of the WUE value. At the next two BBCH stages (65 and 71), the difference decreased and was 10% and 7%, respectively. On average of the three stages, the difference was 10%. Research by a Polish team showed that the addition of apple pomace to the soil results in the formation of larger soil aggregates (Nosalewicz et al., 2021). These studies also showed that the addition of pomace can negatively affect water availability by evaporating faster from the soil and thus reducing the amount of water available to plants. The addition of pomace to the soil as an untreated product can be a source of organic matter. They can also be composted and be a source of both organic matter and plant-available nutrients (Hanc, Khadimova, 2014). In their composition, apple pomace contains significant amounts of carbon (6–8%), nitrogen (0.5–1.2%), as well as other elements important for plants such as potassium, phosphorus, magnesium and calcium (Krasowska, Kowczyk-Sadowy, 2018). When assessing fertiliser properties, the carbon content and carbon:nitrogen ratio (C:N) is important in terms of the rate of organic matter decomposition. Organic matter is decomposed by soil microorganisms, which require the right amount and ratio of carbon to nitrogen to carry out their life processes. In the case of soil, the C:N ratio is usually 12:1, while the most favourable C:N ratio is 20:1 or 24:1. When the ratio is higher, soil micro-organisms begin to utilise nitrogen from the soil, reducing the available pool of this important element for plants. According to a study by Krasowska and Kowczyk-Sadowy (2022), apple pomace is one of the waste raw materials that, due to its low pH (in the range of 3.7–4.3), can have a strongly acidifying effect on the soil. This can have a negative impact on soil pH and microbial activity, as well as plant growth and yield. The results obtained confirm that when irrigation was applied uniformly to all treatments in D3 with the highest addition of pomace to the substrate, there was a positive effect on net photosynthetic efficiency in buckwheat plants. This indicates an indirect positive effect of pomace on the substrate and the functioning of the plant root system. A study by Różewicz et al. (2023) on spring wheat also showed positive effects of the addition of apple pomace to the substrate on photosynthetic processes in plants. According to the authors, however, a negative effect on photosynthetic parameters followed after exceeding a dose of 2 t ha^{-1} pomace, which may be related to a different species response. This was demonstrated by the study of Nosalewicz et al. (2021), who showed a different effect of the addition of pomace to the soil in different plant species. This was related to water availability, as wheat reacted by showing slower growth when water availability was lower, whereas faba beans maintained a constant growth rate after apple pomace application, regardless of water availability. Martínez-Goñi et al. (2024), comparing buckwheat and wheat, showed that buckwheat maintained optimal hydration levels, achieved higher photosynthetic rates, and increased water use efficiency due to increased regulation of the stomatal apparatus and water use efficiency under water deficit conditions. In our own research on buckwheat, it was shown that the WUE rate in buckwheat increased with increased pomace addition to the substrate under equal irrigation. This may have been due to the pomace retaining water in the soil and reducing evaporation, thus making it more available to the plants. Buckwheat has quite high water requirements as its leaves transpire significant amounts of water. Increasing water availability by retaining it in the soil is therefore very important for subsequent seed yield. A study by Fang et al. (2024) showed that the application of plastic mulch on the soil surface significantly increased water availability for buckwheat plants improving WUE. According to the findings of Amelin et al. (2023) a decrease in soil moisture from 70% to 30% results in a 53.7% reduction in photosynthesis intensiveness and 82.1% reduction in transpiration intensity. In our study, the difference in net photosynthetic efficiency had a similar difference in this value, indicating possibly greater retention of water in the soil by the pomace, probably by pectin. Thus, water is available to the plants, and hence photosynthetic and transpiration intensities increase, together with WUE values. In addition, the positive effect on photosynthetic parameters of the addition of pomace to the substrate may have been due to the provision of many micronutrients to the plants, which are not used in traditional mineral fertilization. As demonstrated by Yılmaz et al. (2009), the addition of apple pomace introduces an additional dose of nitrogen and phosphorus to the soil, but also iron and copper which can contribute to more efficient biochemical processes including photosynthesis. The positive effect of pomace addition on stevia biomass has also been achieved with the addition of pomace at 5 t ha^{-1} (Kumar et al., 2013). The increase in plant biomass may be indicative of higher soil richness as a result of the introduction of additional nutrient input, but may also indirectly be an indicator of a more efficient photosynthetic process. Under unfavourable soil environmental conditions, plants activate mechanisms that are responsible for their defence against the acting stress factor. In the event of a shortage of water in the soil, plants close their stomata to limit excessive water loss and wilting. As a result, the normal photosynthetic process is disrupted and thus plant growth is restricted, development is weakened and the weight of individual organs is reduced (Lamaoui et al., 2018).

Table 3. Chlorophyll fluorescence indices at different stages in buckwheat depending on the amount of apple pomace added to the substrate.

Specification	Fv/Fm	PI
BBCH 60 – appearance of first flowers		
K	0.81 b	2.34 b
D1	0.83 a	2.61 b
D2	0.83 a	3.70 a
D3	0.83 a	3.84 a
BBCH 65 – full bloom 50% open flowers		
K	0.80 b	2.42 b
D1	0.83 a	2.60 b
D2	0.83 a	3.63 a
D3	0.83 a	3.91 a
BBCH 71 – beginning of nut development		
K	0.81 b	2.70 b
D1	0.83 a	2.78 b
D2	0.82 a	3.66 a
D3	0.83 a	3.80 a

K – control, D1 – 70 g (of dry matter of pomace per pot), D2 – 140 g, D3 – 210 g

Fv/Fm – index of maximum quantum efficiency of photosystem II; PI – photosystem II performance index

Values in columns signed with different letters (a-b) are significantly different ($\alpha \leq 0.05$)

The efficiency of the PSII photosystem was affected by the addition of pomace to the substrate in the experimental treatments, which was determined by comparing them to the control. However, there were no significant differences in Fv/Fm values for plants growing on the experimental treatments at any of the BBCH stages at which measurements were conducted (Table 3). The level of addition of apple pomace to the substrate had a significant effect on the value of photosystem II performance index (PI). The dose applied on the D2 treatment significantly increased the PI value in plants relative to those growing on the K and D1 treatment. At all the BBCH stages analysed, it was shown that the PI value increased with increasing proportion of pomace addition to the substrat and reached the highest value on the D3 treatment. However, it should be noted that no significant differences were found between plants growing on treatments D2 and D3. Plants growing on the control treatments had lower photosystem II performance index in subsequent stages under study compared to plants growing on the D3 treatment respectively by 64%, 62% and 41%. On average, this difference amounted to 56% of

Table 4. Weight of one thousand buckwheat seeds, seed weight per plant, straw weight, and plant height as a function of the amount of apple pomace added to the substrate.

Specification	Thousand-seed weight [g]	Seed weight per plant [g]	Weight of straw [g]	Plant height [cm]
K	24.00 b	10.10 d	32.19 a	123.5 c
D1	24.08 b	11.41 c	33.44 a	130.7 b
D2	24.14 b	13.52 b	34.68 a	135.3 b
D3	24.59 a	15.32 a	28.60 c	142.5 a

K – control, D1 – 70 g (of dry matter of pomace per pot), D2 – 140 g, D3 – 210 g

Values in columns signed with different letters (a-d) are significantly different ($\alpha \leq 0.05$)

the PI value during the measurements carried out. Adverse environmental conditions, including soil water deficiency or salinity, have a negative impact on plants. The measurement of chlorophyll fluorescence makes it possible to assess the physiological state of the plant and the degree of damage it may have suffered as a result of the stress factor. Under optimal conditions of plant development, the maximum value of this index is 0.83, indicating a normal, undamaged photosynthetic apparatus (Kalaji, Łoboda, 2010). Such a value was found in plants on all treatments with apple pomace added to the substrat, which indicates its positive effect in relation to plants growing on the control treatment in which this value was lower (0.80–0.81). A lowered value of the Fv/Fm parameter indicates unfavourable environmental conditions (e.g. prolonged drought). The assessed value of photosystem II performance index (PI), which is positively correlated with the water resources available to the plants showed that the application of pomace additions of 2 and 3 t ha^{-1} has a significantly positive effect on the functioning of this system. Therefore, the higher the water availability, the higher the value of this indicator (Van Heerden et al., 2007).

The differences in thousand-seed weight were not significant between the seeds from the K–D2 treatments (Table 4). Only the addition of apple pomace to the substrate in the amount used on treatment D3 resulted in a significant increase of 2.5% in thousand-seed weight compared to control.

A greater effect of apple pomace addition to the substrate was found for seed weight per plant. As the addition of pomace to the substrate increased between successive experimental treatments, a significant increase in seed weight per plant was found. The difference between treatment K and D3 was 52%.

In the case of aboveground part, it was found that the application of pomace addition at the highest dose significantly reduced straw weight compared to the other experimental treatments (K, D1, D2) between which there were no significant differences.

However, an increase in plant height was shown when the highest dose of apple pomace was applied to the substrate. Plants from the control treatment reached significantly the lowest height than D1 and D2 treatments. However, the plants from treatment D3 were significantly highest. They were higher than plants from the K treatment by 15%. In field research, buckwheat of the Red corolla cultivar was characterised by an average weight of one thousand seeds of 24.5 g and the weight of seeds per plant of 10.6 g. This indicates that the addition of pomace to the substrate in the amount of 3 t ha^{-1} allowed to achieve an average value of thousand-seed weight for this cultivar and a higher weight of seeds per plant, but these were strictly controlled conditions with optimal soil irrigation. The height of the plants in our study on site D3 was similar to the average height of buckwheat of the Red corolla cultivar obtained by Wolińska et al. (2015), but the plants were lower on the other treatments. The application of the highest dose of apple pomace on treatment D3 may have had a positive effect on the buckwheat crop due to its fertilising properties. Despite the mineral fertilization, pomace also introduced a certain dose of organic matter into the substrate. As shown by Hassona et al. (2024), the application of manure together with mineral fertilisation with phosphorus and nitrogen had a more positive effect on the growth of vegetative parts and grain yield of buckwheat by increasing soil fertility. Studies by many authors have shown that fertilisation with manures has a positive effect on buckwheat yield compared to mineral fertilisation (Jaroszewska et al., 2019; Çürük et al., 2020; Saha et al., 2023). In own study, a significant decrease in straw weight and increase in seed weight per plant was recorded under the highest dose of apple pomace (D3). It appears that this positive response may have been due to a positive increase in soil organic matter content. A similar relationship (increase in biomass and seed yield per plant) was found by Martinez et al. (2022), who used bio-stabilised municipal solid waste as a source of organic matter. Ozyazici and Turan (2021) indicate that an increase in the addition of organic matter in the form of vermicompost, results in an increase in buckwheat yield, which indicated it could replace mineral fertilisation

CONCLUSIONS

1. The addition of apple pomace to the substrate at a rate of 140 g pot^{-1} (corresponded to field volume 2 t ha^{-1}) or higher, resulted in an increase in the net photosynthetic efficiency and effectiveness of transpiration, but showed no significant effect on stomatal conductance.
2. The addition of pomace to substrate at 210 g pot^{-1} (corresponded to field volume 3 t ha^{-1}) showed a significantly positive effect on intracellular CO_2 concentration and WUE.

3. Compared to plants from the control treatment, even the lowest dose of pomace to the substrate caused an increase in the Fv/Fm value, but the increase in dose did not cause significant changes in the plants. A beneficial effect on the PI was found in plants on the D2 treatment, but increasing the dose did not cause a significant increase in its value.

4. The application of the highest pomace rate 210 g pot^{-1} (corresponded to field volume 3 t ha^{-1}) increased yield elements such as; thousand-seed weight, seed weight per plant. It also had a positive effect on plant height.

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Author	ORCID
Marcin Różewicz	0000-0002-3281-5533

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