INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr IV/4/2016, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 1733–1744
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2016.4.4.130

THE EFFECT OF FLAT COVERS ON THE GROWTH AND YIELD OF BROAD BEANS (*VICIA FABA* SSP. *MAJOR*)

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Abstract

The experiment was carried out in 2007–2009, in the central-eastern Poland. The investigated factors were kind of covers: the control without covering, perforated foil with 100 holes per $1m^2$ and polypropylene fibre weighing 17 $g \cdot m^{-2}$, and broad beans cultivars – ‘White Windsor’, ‘Bizon’ and ‘Bachus’. Broad bean seeds were sown at the beginning of the second decade of April, at 50 × 10 cm spacing. Directly after sowing the field was covered by covers, which were left on the plants for 3 weeks. After removing the covers the height of plants was measured. Broad bean was harvested at the stage of milk maturity of seeds. The height of broad bean plants and the number of pods per plant were determined prior to the harvest. During the harvest the weight of pods and the yield of fresh seeds were determined and productivity of seeds was calculated from the weight of pods. Biometric parameters of pods and seeds i.e. length of pods, the number of seeds per pod and length, width and thickness of seeds were measured. It was found that the broad bean covering contributed to increase in the height of plant and yield as well as improvement of the biometric parameters of pods and seeds compared to the control object without covering. The highest yield of pods and seeds was produced by ‘Bizon’ cv. Plants covered by polypropylene fibre yielded best. The seeds of grown cultivars were characterized by similar parameters. Polypropylene fibre covering favoured formation of pods and seeds in the pods but did not cause changes in the seed parameters.

Keywords: broad bean, seed yield, yield quality, covers, plant growth

INTRODUCTION

Early season vegetable production is of particular importance due to the seasonality of fresh vegetables demand and sale. Sales of fresh vegetables in early spring considerably diminishes the phenomenon of seasonality of their consumption. It does not exceed 30% in the first half of the year, because only in the second half-year basic vegetable species are harvested. Success of early field vegetable cultivation is influenced by many factors, among which agrotechnical ones play a crucial role (Rekowska 2007). One of these is direct covering of cultivated plants, which ensures maintaining a higher temperature of the soil and air, higher humidity, but also protects the plants against frost bites (Gordon et al. 2008, Błażewicz-Woźniak *et al.* 2014). Numerous investigations indicate that application of flat covers in vegetable cultivation contributes to accelerating their harvest by several days, increases vegetable crop yield, particularly the early harvested ones (Łabuda and Baran 2005, Siwek and Libik 2005, Biesiada 2008, Olle and Bender 2010, Kosterna 2014, Rosa 2014).). The application of flat covers in vegetable cultivation has also important ecological aspect. The flat covers cut down the occurrence of diseases and pests on plants (Siwek 2004), which reduces the amount of applied chemical plant protection products. The results of cover application depend on their kinds but also on the weather conditions and cultivated plant (Błażewicz-Woźniak 2009, Koudela and Petříková 2009).

Immature broad bean seeds are valued in the first place as a source of easily digestible plant protein, carbohydrates, vitamins and minerals (Kulka and Grzesiuk 1978). Broad bean is the plant requiring early sowing and right date, depending on the climatic regions, falls between the end of March and the second decade of April. Early sowing ensures good and even emergences owing to considerable moisture content in the soil. Delay in sowing due to the weather conditions considerably affects a decline in the seed yield in comparison to the early sowing. The cultivation of broad bean has not only an economic but also an ecological aspect. Broad bean living in symbiosis with bacteria *Rhizobium* contributes to increase the content of nitrogen in the soil. This allows to limit the use of this ingredient in the cultivation of succeeding crops.

The investigations were conducted to determine the effect of flat cover with perforated foil and polypropylene fibre on the yield and biometric characteristics of pods and seeds in three broad bean cultivars.

MATERIAL AND METHODS

The field experiment was conducted in 2007-2009 in central-eastern Poland (52º03'N, 22º33'E) on Luvisol soil (World Reference…2015). The soil had a 30 to 40 cm thick humus horizon and average organic carbon content on the level of 2.1%. The soil pH in H_2O was 5.73. Total microelement contents in 1 dm^3 of soils were as follows: 11 mg NH_4-N; 6 mg NO_3-N; 73 mg P_2O_5; 65 mg K_2O; 380 mg Ca and 40 mg Mg.

The following factors were taken into consideration in the research: the kind of cover control without covers, polyethylene foil cover with 100 holes (ø 10 mm) per 1 m^2 and cover with polypropylene fibre (PP 17 $g \cdot m^{-1}$), and broad beans cultivars: White Windsor, Bizon and Bachus. The experiment was set up in three replications in the split-block arrangement. The area of a single harvested plot was 15 m^2.

The site for broad bean sowing was prepared in the first decade of April, following the agrotechnical recommendations for this crop species. Mineral fertilization was applied to reach the nutrient content in the soil on the level optimal for this plant, i.e. ≥ 30 mg $N \cdot dm^{-3}$, 70 mg $P \cdot dm^{-3}$, 150 mg $K \cdot dm^{-3}$, 60 mg $Mg \cdot dm^{-3}$, 1500 mg Ca dm^{-3} (Sady 2000). Broad bean seeds were sown at the beginning of the second decade of April at the spacing of 50 cm x 10 cm. Immediately after sowing covers were spread over individual combinations and kept over the plants for a period of about three weeks. The plant height was measured after removing the covers. Tending measures comprised de-weeding and plant protection against pests and diseases, according to the obligatory Vegetable Protection Programme (Plantpress 2007).

Broad beans were harvested at the beginning of the first decade of July, at the seed milk maturity. Prior to harvesting, the plant height was measured again and the number of pods per plant was counted. The pod yield and seed yield were determined during the harvest and on this basis biological productivity of the yield was determined. The biological productivity was a difference in the weight of pods and seeds' weight, expressed as a percentage. Samples of 100 pods and 100 seeds were collected from each combination for the assessment of biometric parameters. The number of seeds per pod was counted and pod length, seed thickness by the mark, their length and width were measured.

The obtained results were elaborated statistically using ANOVA test. The significance of differences was determined by means of Tukey test on significance level $P \leq 0.05$. The computations were conducted on the basis of STATISTICA® 12.0 programme.

Legumes reveal a strong diversification resulting from the weather conditions, mainly precipitations distribution and their total, as well as the air temperature during the flowering and ripening period (Szyrmer *et al*. 1992). High air temperature negatively affects growth and yield of crops, whereas chilly weather over the flowering period slows down the ovary development, which affects a lower number of pods per plant (Graham and Ramalli 1997).

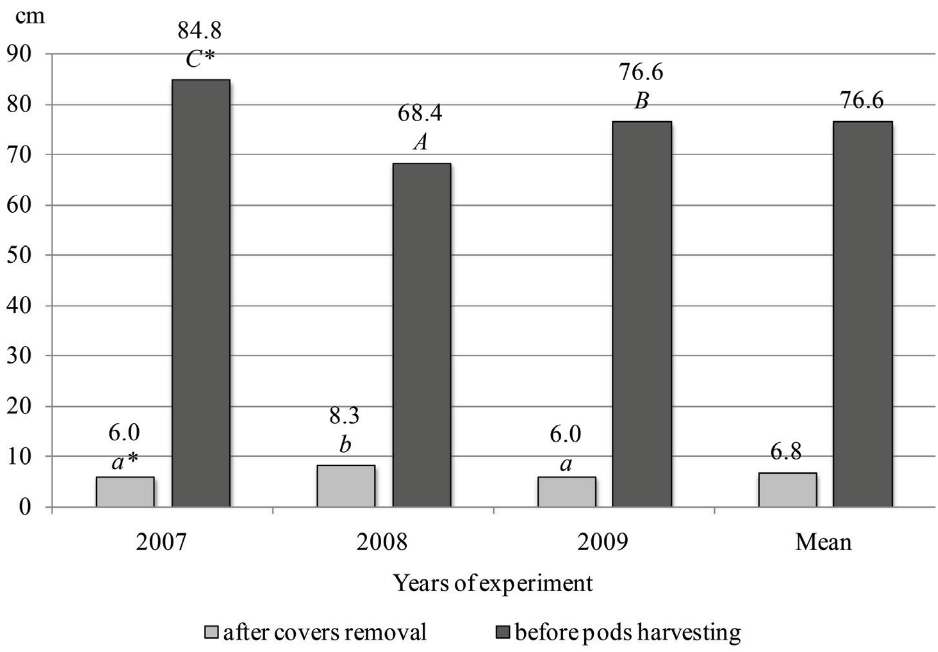
Table 1. Weather conditions during the period of studies

Years	Months					Broad bean vegetation period
	March	April	May	June	July	March-July
Precipitations (mm)						
2007	23.6	21.2	59.1	59.0	70.2	233.1
2008	35.0	28.2	85.6	49.0	69.8	267.6
2009	40.4	8.1	68.9	145.2	26.4	289.0
Average multi-annual total (1951-1990)	27.0	29.4	54.3	69.3	70.6	250.6
Air temperatures (ºC)						
2007	6.3	8.6	14.6	18.2	18.9	13.3
2008	3.1	9.1	12.7	17.4	18.4	12.1
2009	1.5	10.3	12.9	15.7	19.4	12.0
Average multi-annual total (1951-1990)	1.0	7.2	13.2	16.2	17.6	11.0

The weather conditions during the broad bean vegetation period were diversified and not always favourable for its growth and development (Table 1). In April, immediately after the seeds sowing, when the weather conditions determined plant seed germination and initial plant growth, the rainfall amount in 2007 and 2008 was approximate to the multi – annual average for this month (29.4 mm) and much higher than in 2009. A very low amount of rainfall in April 2009 (only 8.1 mm) caused poor plant emergences. In June 2007 and 2008, when the plants were setting and filling pods, a lower rainfall than the multi-annual average (69.3 mm) was registered, respectively by 10.0 and 20.0 mm. In 2009 the rainfall quantity in June over twice exceeded the multi-annual average. In all years of the research broad bean cultivation period was characterized by thermal conditions similar to the multi-annual average for these months.

RESULTS AND DISCUSSION

Irrespectively of the analyzed experimental factors, a considerable diversification in growth and yield of broad bean was observed in the years when the experiment was conducted. Immediately after the covers removal it turned out that the significantly highest plants were cultivated in 2008, whereas in 2007 before the pods harvesting (Figure 1).

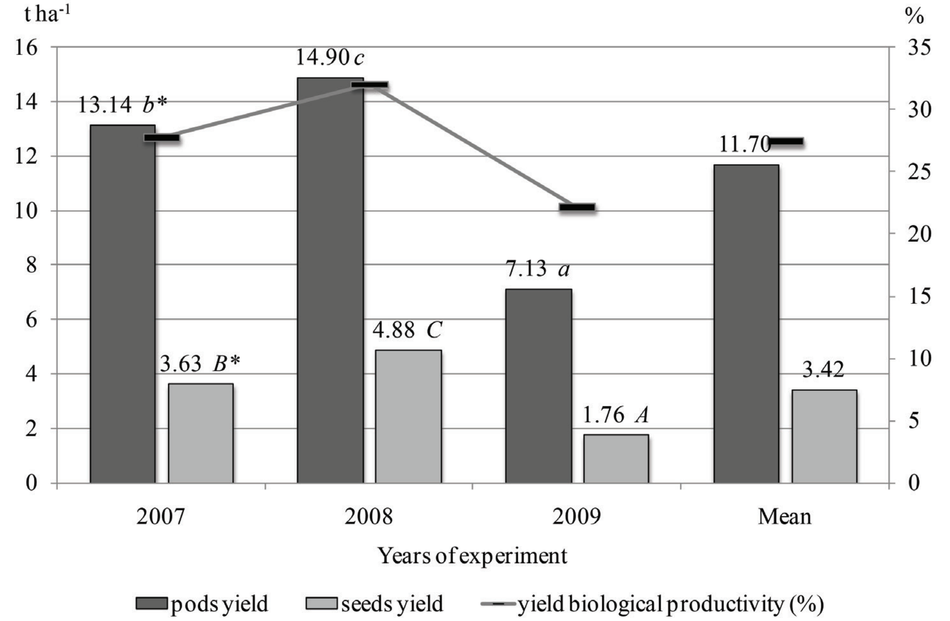


* Values marked with the same small or capital letter do not differ significantly at $P \leq 0.05$

Figure 1. Height of broad bean plants in the years of the experiment

The highest yields of pods and seeds (14.90 Mg $\cdot ha^{-1}$ and 4.88 Mg$\cdot ha^{-1}$) were harvested in 2008, the lowest (7.13 Mg$\cdot ha^{-1}$ and 1.76 Mg$\cdot ha^{-1}$) in 2009 (Figure 2). The yield gathered in 2008 was also characterized by the highest biological productivity (32.8%). The yield biological productivity in 2007 was lower by 5.2% and in 2009 by 8.1%.

Broad bean plants covered by both perforated foil and polypropylene fibre were significantly higher than the uncovered ones at both dates of measurement (Figure 3). Rekowska and Skupień (2007) obtained higher green chive plants with more numerous leaves after the application of covers made of both perforated foil and polypropylene fibre. Immediately before the pods harvesting the highest were White Windsor cv plants. No significant differences in the plant height between the broad bean cultivars were observed after covers removal.



* Values marked with the same letter do not differ significantly at $P \leq 0.05$

Figure 2. Yields of broad bean in the years of the experiment

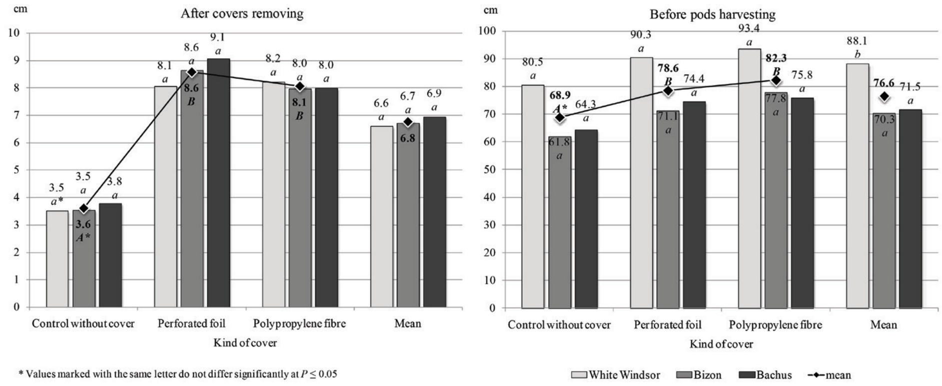


Figure 3. Height of broad bean plants (mean for 2007-2009)

A marked effect of cover on yielding of cultivated broad bean varieties was stated (Figure 4). On average, the highest yield of pods and seeds was gathered from the plants covered by polypropylene fibre. It was significantly higher, respectively by 19% and 28% in comparison with gathered after covering with perforated foil and by 33% and 40% larger in comparison with uncovered control. Increase in green beans yield in effect of covering with polypropylene fibre was also obtained by Łabuda and Baran (2005). Biesiada and Kędra (2012) observed an increase in early season dill yield by 86.8% after using a polypropylene fibre cover. Rekkika *et al.* (2009) harvested heavier lettuce heads cultivated under polypropylene fibre than without covers. In the Author' own studies, the biggest pods yield from the uncovered plants was obtained from White Windsor cv. Irrespective of the kind of cover, the largest pod yield was collected from Bizon variety.

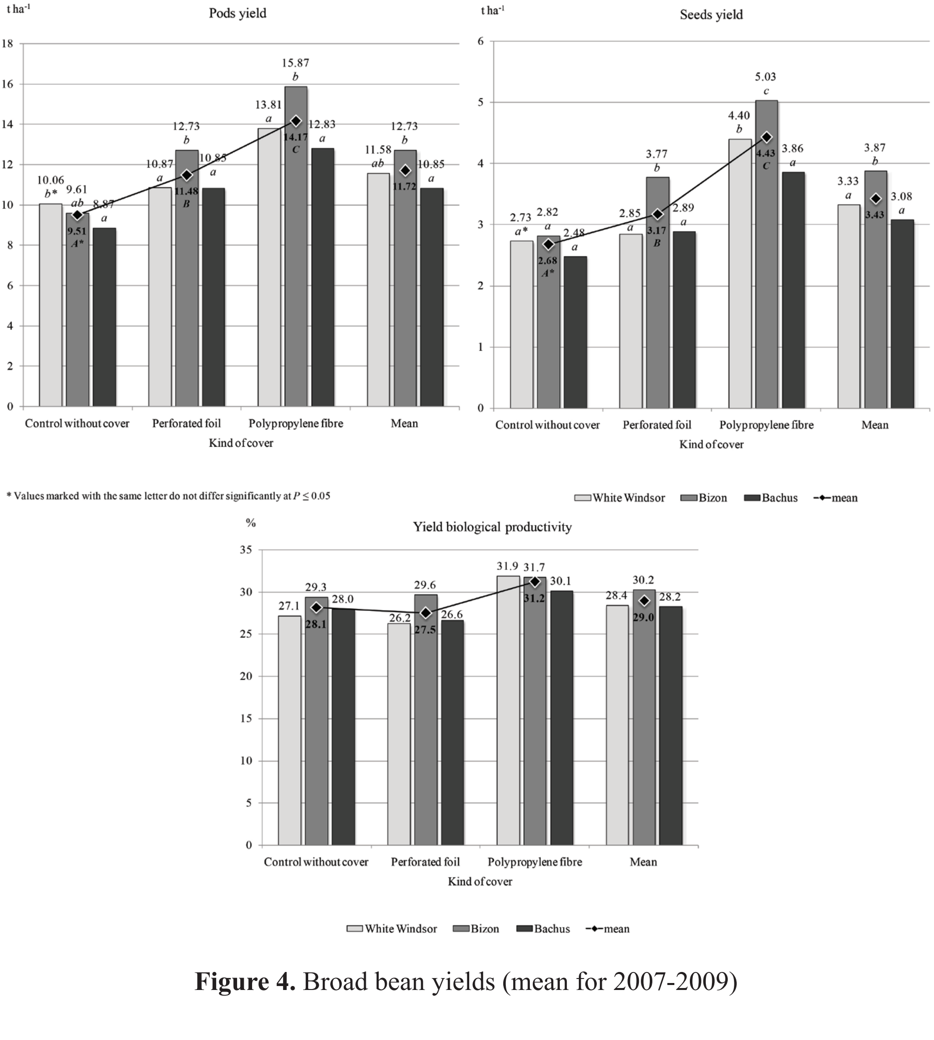


Figure 4. Broad bean yields (mean for 2007-2009)

Considering the cultivated varieties, Bizon broad bean was characterized by the highest seed yield. In the cultivation without covers, seed yield generated by the analyzed varieties was similar and fluctuated from 2.48 Mg $\cdot ha^{-1}$ for Bachus cv to 2.82 Mg $\cdot ha^{-1}$ for Bizon cv. When perforated foil cover was applied, the yield of Bizon cv seeds was by 24.4% higher in comparison with White Windsor seed yield and by 23.3% as compared to Bachus cv. In case of cultivation under polypropylene fibre cover, the yields were bigger, respectively by 12.5% and 23.3%.

Bizon cv was characterized by the highest biological productivity of its yield among the cultivated varieties. The highest biological productivity was obtained after the application of polypropylene fibre covers.

The weather conditions in 2007 did not favour pod setting or their growth, influencing the smallest number per plant and their length (Table 2). Pods gathered in 2009 were the longest. In all years of the experiment broad bean pods contained approximate numbers of seeds, however biometric parameters of seeds were the lowest in 2007.

Table 2. Biometric parameters of broad bean pods and seeds in the years of the experiment

Years of experiment	Number of pods per plant (szt.)	Pod length (cm)	Number of seeds per pod (pcs.)
2007	4.9 a*	12.8 a	3.7 a
2008	5.4 b	13.5 b	3.6 a
2009	5.4 b	14.8 c	3.6 a
Mean	5.3	13.7	3.6
Years of experiment	Seed length (mm)	Seed width (mm)	Seed thickness (mm)
2007	21.9 a	16.1 a	9.4 a
2008	24.2 b	18.7 b	11.4 b
2009	24.2 b	18.7 b	9.5 a
Średnio	23.4	17.8	10.1

*Values marked with the same letter in columns do not differ significantly at $P \leq 0.05$

The covers used in broad bean cultivation significantly diversified the number of pods per plant, their length and number of seeds. Cultivated broad bean varieties differed markedly by the length of pods, but did not differ with the number of pods or the number of seeds (Table 3). Considering the cultivation without covers, Bizon cv had the smallest number of pods per plant. The pods were also the longest among the cultivated varieties, but contained the fewest seeds. In the research of Jadczak et al. (2005) on the assessment of yielding of selected broad bean varieties, Bachus cv produced the longest pods with the greatest number of seeds, characterized also by the greatest length, thickness and width. When the perforated foil cover was used, Bachus cv had significantly greatest number of pods with the longest and most numerous seeds. Bizon cv set the greatest number of pods per plant in cultivation under polypropylene fibre cover. The pods were also the longest. The highest number of seeds in pods of the plants cultivated under polypropylene fibre cover was found in White Windsor broad bean.

Table 3. Biometric parameters of pods and seeds (mean for 2007-2009)

Kind of cover	White Windsor	Bizon	Bachus	Mean
Number of pods per plant (pcs.)				
Control without cover	4.6 ab*	3.4 a	4.7 b	4.3 A**
Perforated foil	5.4 b	5.0 a	5.8 c	5.4 B
Polypropylene fibre	5.7 a	7.0 b	5.8 a	6.2 C
Mean	5.2 a	5.2 a	5.4 a	5.27
Number of seeds per pod (pcs.)				
Control without cover	3.9 b	3.6 a	3.7 a	3.7 B
Perforated foil	3.4 a	3.4 a	3.7 b	3.5 A
Polypropylene fibre	3.9 b	3.7 a	3.6 a	3.7 B
Mean	3.7 a	3.6 a	3.6 a	3.6
Pod length (cm)				
Control without cover	13.6 a	14.2 b	13.1 a	13.7 AB
Perforated foil	12.8 a	13.2 a	14.1 b	13.4 A
Polypropylene fibre	13.4 a	14.5 b	14.1 b	14.0 B
Mean	13.3 a	14.0 b	13.8 a	13.7
Seed length (mm)				
Control without cover	22.9 a	24.5 a	22.8 a	23.4 A
Perforated foil	23.1 a	24.0 a	23.2 a	23.5 A
Polypropylene fibre	22.8 a	24.0 a	23.5 a	23.4 A
Mean	22.9 a	24.2 b	23.2 a	23.4
Seed width (mm)				
Control without cover	16.9 a	17.4 a	17.4 a	17.2 A
Perforated foil	18.9 c	17.9 b	17.3 a	18.0 B
Polypropylene fibre	17.9 a	18.1 a	18.5 a	18.2 B
Mean	17.9 a	17.8 a	17.7 a	17.8

Kind of cover	White Windsor	Bizon	Bachus	Mean
Seed thickness (mm)				
Control without cover	9.8 a	10.5 a	10.7 a	10.3 A
Perforated foil	10.1 a	10.2 a	9.3 a	9.9 A
Polypropylene fibre	9.7 a	10.3 a	10.2 a	10.1 A
Mean	9.9 a	10.3 a	10.1 a	10.1

*, ** Values marked with the same small letter in lines and capital letter in columns do not differ significantly at $P \leq 0.05$

After making biometric measurements it was found that seeds of the cultivated varieties differed significantly by their length (Table 3). Bizon cv seeds were the longest. The width and thickness measured by the mark were approximate. Under the influence of covering the seed width increased considerably, whereas their length and thickness did not differ significantly. Marked differences in the seed width were observed after plant covering with perforated foil. After covering with perforated foil, White Windsor seeds were the widest. In cultivation without covers and after application of polypropylene fibre cover, width of cultivated seeds was approximate.

CONCLUSIONS

1. The largest yields of broad bean pods and seeds, irrespective of variety, were harvested from plants cultivated under polypropylene fibre cover. In cultivation under the fibre, broad bean produced also the highest number of pods per plant was revealed the highest biological productivity of yield.
2. The cultivated varieties, irrespectively of the kind of covers, were setting an approximate number of pods with similar number of seeds.
3. Biometric parameters of seeds of the cultivated broad bean varieties were similar. Only Bizon cv seeds had better ones.

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Received: 27.10.2016
Accepted: 01.12.2016