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Wheat Straw in the Function of Obtaining Animal Feed and Biofuel

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Abstract

Wheat is primarily thought as a grain crop, but it is a useful winter pasture and forage source. Cereal plants are used to produce very nutritious roughage for livestock maintenance during winter and wheat forage is as extremely valuable for forage. Harvest residues are increasingly used for energy purposes why is the rate of increase in the use of alternative fuels is growing significantly. Commercial production should be economically and environmentally friendly so that renewable fuels are an adequate substitute for fossil fuels, at the same time protecting and caring for the environment. The paper examines three wheat genotypes in the goal to obtain biogas from plant biomass. The results showed that the genotype had a significant impact on biomass and biofuel productivity. The highest biomass and biogas yields were obtained in the varieties Simonida, 3.85 t ha-1 and 388.93 m3 ha-1. The values for biogas yield were higher in 2019 (386.00 m3 ha-1) compared to 2018 (352.55 m3 ha-1). Biomass yield was in a positive insignificant correlation with biogas yield (r = 0.43).

The essence of converting harvest and all other plant residues into biofuels is not only obtaining as much energy as possible but also applying a sustainable production method from which everyone will have benefit.

Keywords: *Biomass; Biofuels; Economic and Environmental Profitability; Wheat Crop Residues; Renewable Energy Sources*

Introduction

Wheat (*Triticum aestivum* L.) is one of the oldest and most important cultivated plants because over 70% of the world's population use wheat bread for feeding [7-9,13,20,21,24,25]. Wheat is generally thought as a grain crop, but it can be a useful winter pasture and forage source [4]. Cereal plants are known to produce very nutritious roughage for livestock maintenance during winter and wheat forage is as valuable as oat forage [4,22]. Wheat forage may be grazed or cut for hay and silage (Figure 1a). It is also possible to grow wheat as winter pasture and then cut it for hay during the spring [3]. When wheat forage is used for hay or silage, it should be cut at the boot stage or at very early head emergence. At these early stages, wheat forage is very palatable and has a high nutritive value. When cut later (at the early milk stage of the grain), its nutritive value is lower [2]. Wheat forage may be grazed or cut for hay and silage. It is also possible to grow wheat as winter pasture and then cut it for hay during the spring [3].

Straw is an agricultural by-product, which is a dry cereal stalk, after the separation of grain and its husk. It makes up about half of the grain yield of cereals (wheat, barley, oats, triticale, rye and rice). Straw can be used in several ways: as a biofuel, then as fodder, a mat for domestic animals, for filling mattresses, for knitting baskets, hats and other household items, for building and covering residential and commercial buildings, for protection against erosion, for the production of substrates for growing mushrooms [9] for the packaging of glass and other goods sensitive to impact, in the chemical industry, pharmaceutical industry and cosmetics, etc.

After the machine harvest, the harvest remains of straw and husk remain in the fields. The share of harvest residues in the total yield of aboveground biomass is different and depends on the type of grain, genotype, agroecological conditions and applied agrotechnics [10]. In newer varieties of real cereals, which have lower stalks and smaller clusters, the share of harvest residues in the total yield is 40 - 50%. With a grain yield of 5,000 kg ha^{-1}, 3,500 - 4,500 kg ha^{-1} straw can be obtained. According to the results of the research, which are stated by British authors, if the straw of cereals, grown only in the area of the eastern part of the Midlands, were used to obtain biofuels, the amount of obtained energy would cover about 1.5% of British consumption. However, the point of view of local farmers is explicit and they insist that these secondary products should be returned to the land by ploughing or as manure, which has the far greater importance on soil fertility and further plant production. Finding the optimal solution for the use of cereal straw should be the subject of further researches [5].

According to recent literature data, it is estimated that over 15,000,0000 tons of biomass remain in the total plant production of our country annually. It is estimated that the amount of biomass will increase from year to year depending on raising the level of agrotechnical measures, changes in the structure of sowing, as well as the way of using and further processing of agricultural products. The main agricultural products (cereal grains, legumes and oilseeds) are often used to obtain various biofuels (solid, liquid and gaseous). With the long-term and increasing use of the main products for energy purposes, the amount of food necessary for the growing population will be gradually reduced in the world. The consequence of reduced food quantities is affecting the rise in prices, which can cause restlessness in the wider geographical area, especially in developing countries. Therefore, it is necessary to improve industrial plants that can be used as the non-nutritious part of plants for the production of biofuels, i.e. the harvest residues of field or other crops and plantations (Figure 1b). In the past decades, many countries, under strong pressure to improve energy security from the aspect of environmental protection, but also to reduce dependence on imports, began to develop programs for the production of alternative biofuels (methane, ethanol and biodiesel) from plant products [11,14,21]. The authors state that in Europe, wheat straw are viewed as one of the primary feedstocks for the Biobased economy given the volume of straw produced every year. Wheat straw is a low-cost biomass, which is used for various purposes in many countries (animal bedding, biofuels, straw being marketed as a feedstock for the biobased economy, etc).

Aim of the Study

This study was aimed to examine the productivity of wheat during two years of research in biogas production. The obtained data indicate a great possibility of more rational use of wheat secondary products (wheat straw) for energy purposes.

Materials and Methods

Production parameters of wheat in period 2017/2018 - 2018/2019 are analyzed in this paper. Data on soybean production are taken from the FAO website 2020 [28]. At the second part of the research, in 2017/2018 - 2018/2019 period, trials were performed by a random block system in three repetitions with the size of the basic plots of 10m^2 on the site Ilandza, Serbia, with varieties: Simonida and Ilina (NS) and Solehijo (KWS). During the experiment, standard cultivation technology for wheat was applied. Fore crop was soybean. Sowing was

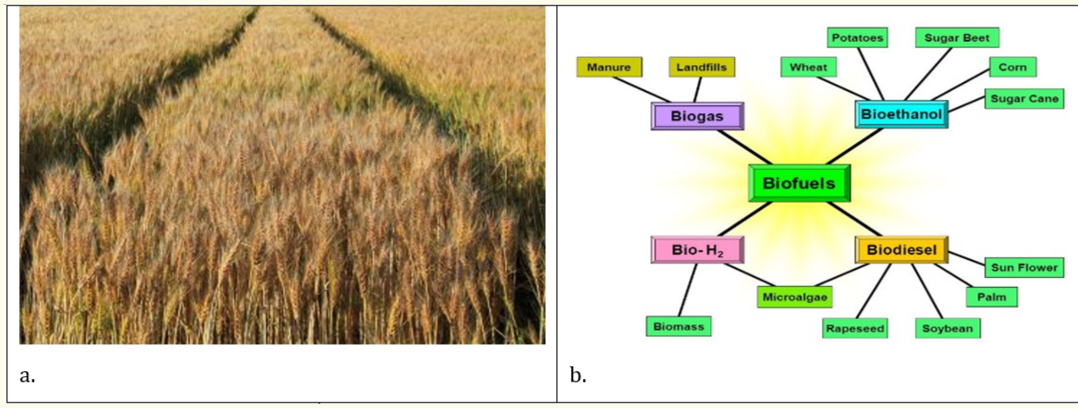

Figure 1: *Wheat, a., and Biofuels Production, b. https://slideplayer.com/slide/6635491/.*

done in the optimal time. During the vegetation period, mechanical and chemical measures of crop care were applied. Harvesting was performed at technological maturity, and then samples were taken, from each elementary plot, for the examined parameter (biomass yield). In the phase of full maturity, above-ground biomass is harvested from each plot by hand. The plant material was dried, with constant turning, after which the biomass yield was measured. Crop biomass data were fitted to the logistic curve by Verhulst [23]. The remaining biomass was processed by a hammer mill and crushed, placed in a fermenter from which biogas was obtained. Data were subjected to Analysis of variance (ANOVA). Correlation analysis was used to test traits correlation. Analysis of variance and correlation analysis was performed using Statistica 12 and presented in tables and graphs.

Meteorological data: The meteorological data for 2017/18, 2018/19 and long-term (1967–2017) period were obtained from the meteorological station located near the experimental field (Table 1). Total vegetation precipitation was 484.2 mm in 2017/2018 and 538.3 mm in 2018/19 while average monthly temperatures were 9.55ºC and 9.57ºC (Table 1).

Parameter	10.	11.	12.	1.	2.	3.	4.	5.	6.	X
Temperature (T, °C)										
2017/2018	11.2	8.6	2.8	-0.2	3.2	9.5	11.0	17.2	22.7	9.53
2018/2019	11.5	9.0	2.0	0.0	3.1	8.5	11.1	18.0	22.1	9.57
Long term T	12.6	7.5	2.0	0.8	2.6	7.6	13.0	18.0	22.0	9.56
Precipitation (P, mm)										
2017/2018	36.2	41.6	33.2	47.2	20.3	32.6	67.2	90.0	116.0	484.2
2018/2019	48.3	52.4	62.1	48.3	39.2	52.0	72.1	93.4	70.5	538.3
Long term P	48.8	52.0	45.8	51.0	55.2	55.8	48.9	82.3	84.2	478.1

Table 1: *Meteorological data, 2017/2018 - 2018/2019, MS near Ilandža, Serbia.*

In 2017/2018 lower precipitation was recorded compared to 2018/2019. In Serbia, climatic conditions are variable both in terms of atmospheric precipitation and in terms of oscillations in air temperature. These changing climatic conditions are the most common cause of reduced yields and poor seed quality of field crops [20]. Environmental conditions in the Pannonian Plain are characterized by the appearance of high temperatures and water deficit after anthesis, resulting in the decreased duration of grain filling period and grain weight reduction [6,13,15].

Results and Discussion

Wheat is the most important food grain source for humans. Wheat is grown on more than 216.36 million ha, larger than for any other crop, and world trade is greater than for all other crops combined (Table 2). World average wheat yield in tested period was 3.48 t ha^{-1} and production reached high of 762 million tonnes in 2018 (Table 2).

Parameter	World	Asia	Europe	America	Africa	Oceania	EU	Serbia
Area harvested, 000 ha								
2017/18	218425	100282	61879	33580	10451	12232	26010	556.1
2018/19	214292	96964	60611	35528	10227	10961	25496	643.1
$\overline{X}$	216358	98623	61245	34554	10339	11596	25753	0.600
S. Dev.	29922	2346	896	1377	158	898	363	61.5
Share, %	100	45.58	28.31	15.97	4.78	5.36	11.90	0.028
Yield, t ha^{-1}								
2017/18	3541	3342	4402	3189	2558	2634	5857	4092
2018/19	3425	3385	3995	3182	2864	194	5414	4574
$\overline{X}$	3483	3363	4199	3185	2711	1414	5636	4333
S.Dev.	82.0	30.4	287.8	4.9	216.4	1725.3	313.3	340.8
Production, 000 t								
2017/18	762877	335042	272381	107096	26733	32224	152339	2276
2018/19	734045	328220	242139	113083	29289	21312	138049	2942
$\overline{X}$	753761	331631	257260	110089	28011	26768	145194	2609
S.Dev.	27882	4823	21384	4233	1807	7716	10104	471
Source: FAO 2020, Author's calculation								

***Table 2:** Wheat area and production in world, 2017/2018-2018/2019.*

Asia has the largest land area devoted to wheat production (45.58%), followed closely by Europe (28.31%), America (15.97%), Oceania (5.36%) and Africa (4.78%) (Table 2).

In two-year period, the average biomass yield was 3.76 t ha^{-1}. The genotype x year interaction had a statistically significant effect on biomass yield. Variety and year did not have a statistically significant effect on biomass yield. The highest biomass yields were obtained in the varieties Simonida, 3.85 t ha^{-1} and Solehija, 3.82 t ha^{-1}. The values for biomass yield were higher in 2019 (3.95 t ha^{-1}) compared to

2018 (3.58 t ha^{-1}) (Table 3 and figure 2a). The average yield of biogas obtained from wheat biomass in the two-year period was 385.78 m^3 ha^{-1}. The genotype x year interaction had a statistically significant effect on biomass yield. Variety and year did not have a statistically significant effect on biomass yield (Table 3).

Parameter	Level of Factor		No	Biomas yield Mean	Biomas yield St.Dev.	Biogas yield Mean	Biogas yield Std. Dev.
Total			18	3763	0.406	385.78	4.21
Genotype	Simonida		6	3850	0.404	388.93	0.84538
Genotype	Solehija		6	3824	0.202	387.03	1.43759
Genotype	Ilina		6	3617	0.549	381.37	0.33862
Year	2018		9	3577	0.345	385.56	4.198
Year	2019		9	3949	0.393	386.00	4.462
G x Y	Solehija	2018	2	3.863	0.117	390.73	0.751
G x Y	Solehija	2019	3	3.980	0.279	391.34	2.082
G x Y	Ilina	2018	3	3.267	0.252	381.23	0.208
G x Y	Ilina	2019	3	3967	0.569	381.50	0.435
G x Y	Simonida	2018	3	3600	0.361	384.70	0.754
G x Y	Simonida	2019	3	3900	0.458	385.17	1.026

Parameter			Genotype, G	Year, Y	G x Y
Biomass yield	LSD 0.1	0.5	0.467	0.381	0.660
		0.656	0.536	0.929	
Biogas yield	LSD 0.1	0.5	1.341	1.095	1.866
		1.887	1.541	2.668	

Table 3: *Wheat biomass yield, кg ha^{-1}, and biogas yield, m^3 ha^{-1}, 2017/2018-2018/2019.*

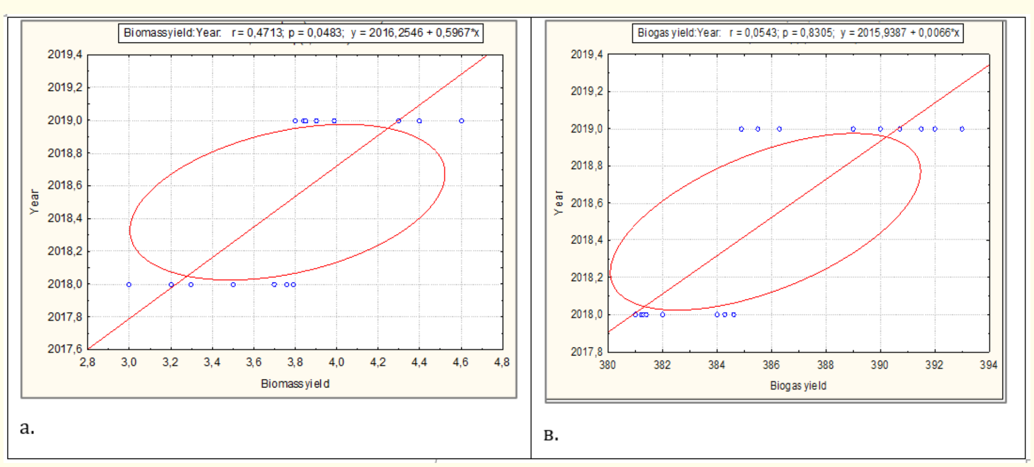

Figure 2: *Influence of the year on of wheat biomass, kg ha-1, (a) and biogas yield, m3 ha-1, (b) 2017/2018 - 2018/2019.*

Biomass yield was in a positive insignificant correlation with biogas yield (r = 0.43) (Table 4). The highest biogas yields were obtained in the varieties Simonida, 388.93 m^3 ha^{-1} and Solehija, 387.03 m^3 ha^{-1}. The values for biogas yield were higher in 2019 (386.00 m^3 ha^{-1}) compared to 2018 (352.55 m^3 ha^{-1}) (Table 3 and figure 2b).

Parameter	Biomass yield	Biogas yield
Biomass yield	1.00	0.43
Biogas yield	0.43	1.00

Table 4: *Correlation of tested traits.*

These results are similar to those obtained by Mirosavljević., *et al.* [17]. The authors state that their tests indicate that the grain and dry matter yield were significantly influenced by sowing date and genotype in both seasons. Sowing in the first and second period gave the highest yield of grain and biomass. A positive relationship between crop biomass and grain yield was found in both species. Wheat had similar tendencies in the accumulation of dry matter. Biomass in maturity was positively related to the length of the vegetation period, and negatively related to the estimated mean absolute growth rate. Early sowing enables the prolongation of the duration of different phases of dry matter accumulation, leading to a significant increase in yield and dry matter in barley and wheat.

Fodder also depends upon seasonal crops, Yaqoob reported that the fodder availability and prolificacy highly effects birth weight, weaning weight, weight at 6 and 9 months age, and pre- and postweaning growth rates of Dera Din Panah goat [26,27].

USDA expects global wheat production for 2019/2020 at a new record of 777 million metric tons (MMT). Wheat is a source and of animal feed, in years where harvests are adversely affected by rain and significant amounts of the grain are made unsuitable for food use. Such wheat grain is often used by industry to make adhesives, paper additives, even in the production of alcohol, biodiesel and others. Wheat straw are agricultural side products. Straw is a primary biomass residue. Wheat straw are a lignocellulosic biomass. Contains a high amounted of inorganic components and ash. Straw is a major feedstock for the biobased economy. Wheat straw is an abundant agricultural by product with a very commercial value. The yield of wheat straw depends on different parameters such as a climate and agronomic factors, however an average yield of 1.3 - 1.4 kg of straw per kg of wheat grain is reported as the most topical one for various areas [17-19].

Estimates of straw yield are made based on the grain production (ton grain per ha) and converted to straw yield by applying a straw: grain ratio. The resulting straw yield should be seen as a theoretical estimate of straw that could be collected, however actual straw yields are generally lower as there are technical and climatological limits (e.g. straw collection machinery, field specific factors, rainfall) and economical limits to collection of straw, that limit the amount of straw that can be extracted from the field in a specific situation.

Wheat straw is lignocellulose biomass is an attractive feedstock for biofuel production. The biochemical composition of wheat straw is characterized by a typical composition of an agricultural - based lignocellulosic residue: average cellulose is 33 - 52%, hemicellulose 10 - 39%, 5 - 30% lignin, 1.5% lipids, 3 - 6% protein, as well as a number of minor organic components: 52 - 87% volatiles, 1 - 23% ash, 46 - 53% ash, 6% H, 10 - 50% O, 1 - 2% N, 06% S etc (www.ecn.nl/phyllis).

Facilities are increasingly using pelleted straw of field crops, both large industrial plants and small businesses and households. Straw can be used for the production of briquettes and pellets, a solid fuel suitable for use in smaller boiler plants, for example for heating residential buildings. Straw can also be used to obtain liquid biofuels (ethanol) because it has large amounts of carbohydrates. Today, in addition to the requirements for fuel quality, there are more and more requirements for low exhaust emissions of toxic gases and obtaining fuel from renewable energy sources. The general aim is to produce new fuels based on new technologies that offer significant potential in improving air quality and reducing gas emissions, all in the goal to protect the environment and influence of global climate change. However, the complete penetration of new technologies on the market is a long process, and some of the new technologies are still in the development phase and require significant investments until the final application [11]. The situation is similar in the field of fuel application technologies. All these circumstances force world factors in the automotive industry and energy in general, to develop new types of fuels from renewable sources from biomass of agricultural crops.

Currently, the transportation sector in many countries is for more than 80% dependent on oil imports. One of the main drivers for biofuels therefore is to reduce the dependency on imported oil. Another very important driver for biofuels, is the reduction of greenhouse gas emissions in the transportation sector. Biofuel production may lead to new economic impulses for agriculture and agroindustry, and it may add value to by-products, in case by-products or wastes are used to produce biofuels. The main biofuels currently used in the world are bioethanol (or alcohol), and biodiesel. In the world, bioethanol production by far exceeds the biodiesel production. The main producers are Brazil, and the United States [1,12]. The 30-country member International Energy Agency, IEA forecast calls for a 20 percent increase in global ethanol output to 130 billion litres from 110 billion litres between 2020 and 2024.

Conclusion

Wheat is primarily thought as a grain crop, but it is a useful winter pasture and forage source. World average production reached high of 762 million tonnes in 2017/18. Wheat straw are agricultural side products, straw is a primary biomass residue. Harvesting wheat residues can be successfully used and for energy purposes. As commercial production trends to be economically and environmentally friendly, renewable fuels will be an adequate substitute for fossil fuels. Biofuels produced by new technologies offer great potential in improving air quality and reducing gas emissions, but also environmental protection and the impact on global climate change.

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Conflict of Interest

The authors declare no conflicts of interest.

Bibliography

1. Bakker R., *et al*. "Rice straw and Wheat straw. Potential feedstocks for the Biobased Economy". NL Agency (2013): 1-31.
2. Boyles S and Eastridge M. "Wheat for hay". C.O.R.N. Newsletter, Arnold, G (Edition). Ohio State University Extension Agronomy Team (2010).
3. Bruening B. "Wheat forage production. Wheat science news". University of Kentucky, Cooperative Extension Service, Lexington, USA (2007).

4. Cash D., *et al*. "Forage yield and quality of 'Willow Creek' forage winter wheat". Montana State University Extension Service. Bozeman, USA (2007).

5. Copeland J and Turley D. "National and Regional Supply/Demand Balance for Agricultural Straw in Great Britain". CSL (2008).

6. Darroch BA and Baker RJ. "Grain filling in three spring wheat genotypes: statistical analysis". *Crop Sciences* 30 (1990): 525-529.

7. Dončić D., *et al*. "Economic analysis of wheat production and applied marketing management". *Agriculture and Forestry Podgorica* 65.4 (2019): 91-100.

8. Đekić V., *et al*. "Grain yield and yield components of winter barley". *Agriculture and Forestry, Podgorica* 63.1 (2019): 179-185.

9. Glamočlija Đ., *et al*. "Alternative field species in conventional and organic cultivation system". Monograph Belgrade, Serbia (2015): 1-350.

10. Ikanović J and Popović V. "Organic plant production". Book, University Bijeljina, Faculty of Agriculture (2020): 1-235.

11. Ikanović J., *et al*. "Mogućnost većeg korištenja kukuruza kao bioenergenta". *Journal of Institute of PKB Agroekonomik* 24.1-2 (2018): 49-58.

12. Lakić Ž., *et al*. "Fodder plants and cereals in the function of protecting the soil from degradation". Monograph. Banja Luka (2018): 1-405.

13. Ljubičić N., *et al*. "The impact of ZnO nanoparticles application on yield components of different wheat genotypes". *Agriculture and Forestry* 66.2 (2020): 219-229.

14. Milanović T and Popović V. "Analysis of soybean production and biogas yield to improve eco-marketing and circular economy". *Economics of Agriculture, Belgrade* 67.1 (2020): 141-156.

15. Mirosavljević M., *et al*. "Breeding progress in grain filling and grain yield components of six-rowed winter barley". *Zemdirbyste-Agriculture* 107.3 (2020): 271-278.

16. Mirosavljević M., *et al*. "Dry matter accumulation of winter wheat and barley at different sowing dates". *Field and Vegetable - Ratarstvo i Povrtarstvo* 55.2 (2018): 87-94.

17. Momayez F., *et al*. "Sustainable and efficient sugar production from wheat straw by pretreatment with biogas digestate". *RSC Advances* (2019): 47.

18. Munakamwe Z., *et al*. "The effect of genotype and agronomic factors on crop growth and yield in field peas (*Pisum sativum* L.) as influenced by radiation interception and utilization". *Austral Journal of Crop Sciences* 8.5 (2014): 680-688.

19. Pagelow Jr EJ., *et al*. "The Gompertz function as a model for cotton hypocotyl elongation". *Agronomy Journal* 69 (1977): 875-878.

20. Popović V. "Influence of agro-technical and agro-ecological practices on seed production of wheat, maize and soybean". PhD. Thesis, University of Belgrade, Faculty of Agriculture (2010): 1-145.

21. Rakaščan N., *et al*. "Effect of genotypes and locations on wheat yield components". *Agriculture and Forestry* 65.1 (2019): 233-242.

22. Shuja MN., *et al*. "Evaluating the response of wheat genotypes to forage clipping". *International Journal of Agriculture and Biology* 12 (2009): 111-114.

23. Verhulst PF. "A note on population growth". *Journal of Mathematical Physics* 10 (1838): 113-121.

24. Ugrenović V., *et al*. "Analysis of spelt variability (*Triticum spelta* L.) grown in different conditions of Serbia by organic conditions". *Genetika, Belgrade* 50.2 (2018): 635-646.

25. Živanović Lj., *et al*. "Influence of variety and hybrid on grain yield of wheat, soybean, corn and sunflower". *Journal of Institute of PKB Agroekonomik* 23.1-2 (2017): 39-49.

26. Yaqoob M., *et al*. "Production performance of Dera Din Panah goat under desert range conditions in Pakistan". *Tropical Animal Health and Production* 41.7 (2009): 1413-1419.

27. Nabi Bux Solangi., *et al*. "Growth Performance of Young Pateri Cross Breed Goat Supplemented with Selenium Yeast". *EC Veterinary Science* 4.4 (2019): 266-272.

28. FAO. Faostat.fao.org/; Faostat | © FAO Statistics Division (2020).

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