

Research Application Summary

Value-addition of cereal crop residues for improving the income, nutrition and performance of small-stock of small-scale farmers using low technology oyster mushroom production in Botswana

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Abstract

Grain cereal production gives rise to crop residues in the farm once the grain is harvested or processed. The common residues include straw and husks of small grains such as wheat, barley, rice, sorghum and pearl millet and stalks, husks and cobs of maize. Most of these crop residues are either burnt, ploughed under or processed into animal feed. In Botswana small-scale cereal yields are very low averaging 110kg/ha and the crop residues are normally grazed in situ or ploughed in and are not a source of direct additional income. The use of cereal residues in oyster mushroom (*Pleurotus* spp.) production is one way of increasing income from a unit of land and improving the diet of farmers since the mushrooms are a high-value crop and nutritious. The spent mushroom substrate can be incorporated into small-stock feed. Botswana's rain-fed cereal grain yields are expected to decline further as rainfall becomes more erratic and temperatures rise due to climate change. Incorporation of oyster mushroom production into the cereal production system in Botswana can mitigate against food insecurity in that farmers can get additional income from selling mushrooms. The innovation of this study is the value-addition of low quality crop residues through production of high-value mushrooms while the spent mushroom substrate can be a high-value animal feed. The incorporation of mushroom production in cereal production could result in higher income per hectare for small-scale farmers. This paper reviews the potential of adopting oyster mushroom production for enhancing smallholder incomes in Botswana.

Key words: Cereal production value-addition, crop residues, spent mushroom substrate, *Pleurotus* spp.

Resume

La production céréalière donne lieu à des résidus de récolte dans la ferme une fois que les grains sont récoltés ou transformés. Les résidus couramment rencontrés incluent la paille

et les balles de petits grains comme le blé, l'orge, le riz, le sorgho et le mil perlé, ainsi que les tiges, enveloppes et épis de maïs. La plupart de ces résidus de récolte sont soit brûlés, enfouis ou transformés en aliments pour animaux. Au Botswana le rendement de cultures de céréales à petite échelle sont très faibles et estimé à 110 kg / ha. Les résidus de cultures sont normalement broutés sur place par les animaux ou enfouis dans le sol lors du labour et ne constituent pas encore une source de revenu. L'utilisation de résidus de céréales dans la production de pleurotes (*Pleurotus* spp.) est un moyen d'augmenter les revenus provenant d'une parcelle agricole et d'améliorer le régime alimentaire des agriculteurs car les champignons constituent une importante culture à grande valeur nutritive. Le substrat de champignon usé peut être incorporé dans l'alimentation de petit bétail. Il est projeté que les rendements de cultures pluviales de céréales au Botswana diminueraient de plus, en ce sens que les pluies sont plus irrégulières et les températures augmentent à cause du changement climatique. L'incorporation de la production de pleurotes dans le système de production de céréales au Botswana peut réduire l'insécurité alimentaire en ce que les agriculteurs peuvent obtenir un revenu supplémentaire de la vente de ces champignons. L'innovation de cette étude est la valeur ajoutée des résidus de récolte grâce à la production de champignons à grande valeur nutritive et l'utilisation du substrat de champignon usé comme un aliment pour bétail à haute valeur ajoutée. L'incorporation de la production de champignons dans la production céréalière pourrait se traduire par des revenus plus élevés par hectare pour les petits exploitants agricoles. Cet article examine le potentiel de l'adoption de la production de pleurotes pour améliorer les revenus des petits exploitants au Botswana.

Mots clés: valeur ajoutée de la production céréalière, résidus de récolte, substrat usé de champignons, *Pleurotus* spp.

Background

Small-scale cereal crop production in Botswana is seriously hampered by erratic and poorly distributed rainfall, persistent droughts and pests resulting in low yields and income per hectare. Average grain yield figures for small-scale farmers for 2008/09 to 2011/12 seasons for maize, sorghum and millet were 106.9 kg/ha, 124.6 kg/ha and 93.3 kg/ha, respectively (Department of Crop Production, Ministry of Agriculture, unpublished report). Grain yield figures for 2012 for maize, sorghum and millet for small-scale and commercial farmers were 53 kg/ha, 144kg/ha and 153 kg/ha, and 580 kg/ha, 1476 kg/ha and 660 kg/ha, respectively (Statistics Botswana, 2014). The 2016/2017 Botswana Agricultural Marketing Board (BAMB) producer prices for maize, sorghum and millet are BWP2.55/kg (www.bamb.bw). Most small-scale households are not food-sufficient in grains and have to use income generated from livestock or elsewhere to purchase these staples.

Cereal grain yield is the main indicator of productivity for small-scale farms while the residues are ploughed under, burnt or grazed upon by livestock (Madibela and Lekgari, 2005). Based on a ratio of 1:5 of grain to stover (Kossila, 1988), the 2008/09 - 2011/12

average stover yield for maize, sorghum and millet in Botswana were 534.5 kg/ha, 623.2 kg/ha and 466.6 kg/ha, respectively. Stover can replace part of the roughage needed by ruminants provided the feeding value, especially nitrogen and digestibility, is improved by urea treatment or judicious supplementation with on-farm legume forage such as *Lablab purpureus* (Madibela and Lekgari, 2005). Biodegradation of *Digitaria exilis* Stapf (acha) stover by *Pleurotus ostreatus*, *P. tuber-reguim* and *P. pulmonarius* has been found to improve crude protein, organic matter digestibility, rate of gas production, volumes of gas production and reduce fibre and cellulose content (Sarnklong *et al.*, 2010, Akinfemi, 2009, 2010 and 2012). The current study seeks to address the problem of low income per unit area of land of small-scale cereal farmers by adding value to the stover through oyster mushroom production. The average price for fresh oyster mushrooms is BWPula 125/kg which is much higher than the producer price of BWPula 2.55. Fresh mushrooms should, therefore provide additional income and or improved nutritional status of households while the spent mushroom substrate (SMS) will be used as small stock feed or soil conditioner.

Role of oyster mushrooms in climate-smart cereal production

According to the FAO (2013) “Climate smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. As such CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible”. In Botswana, rain-fed small-scale cereal production is becoming less sustainable due to the frequent droughts which have resulted in low grain yields or total crop failures. As a result Botswana is not food sufficient in grains which have to be imported annually. The small-scale farmers’ income from cereal production under current yield levels cannot sustain their livelihoods and some are abandoning farming activities to engage in government poverty eradication programmes for their incomes. There is need, therefore, to adopt CSA and in particular climate-smart cereal production in Botswana. Incorporation of oyster mushroom production into the cereal grain production cycle is justified. The current cereal farming cycle where there is little activity after harvest and before onset of rains has room for farmers to engage in value addition activities such as oyster mushroom production.

Oyster mushrooms are relatively easier to grow than other species such as button and shiitake because they require minimal skills for substrate preparation and structures for environmental control (Marshall and Nair, 2009). The mushrooms are cultivated on substrates rich in cellulose and lignocellulose because of their ability to digest these complex compounds (Oei, 1996, and 2003). Commonly used substrates include maize stalks and cobs, sorghum stalks and chaff, pearl millet stalks, wheat straw, rice straw and husks, coffee hulls, cotton residues, sawdust, banana leaves, water hyacinth weed, wild grasses and leaves of some trees (Tasmin, 1988; Obodai *et al.*, 2002; Khonga, 2003; Shah *et al.*, 2004; Poppe, 2004; Khonga *et al.*, 2005; Ngezimana *et al.*, 2008; Jongman *et al.*,

2010; Seni *et al.*, 2012; Alemu, 2014). Oyster mushroom yield is expressed as biological efficiency (BE) which is the fresh weight of mushrooms divided by the initial fresh or dry weight of substrate and averages 50-100% under Botswana conditions (Khonga, 2003). Using a BE of 50% (substrate wet weight basis) the potential yield of mushrooms from 550 kg/ha of crop residues is 270 kg/ha resulting in a gross income of BWP33,840 which is much higher than the income from grain of BWP280. Incorporation of oyster mushroom production in a cereal cropping system has, therefore great potential of increasing farm income per unit area of farmland. The mushroom spent substrate is a good soil conditioner if incorporated into the soil and can also be used as feed for small stock.

Oyster mushrooms are nutritious with excellent fragrance, texture and taste with relatively higher protein content than most vegetables. Other compounds found in the mushrooms are known to improve the immune system, lower bad cholesterol and high blood pressure and fight cancer Khatun *et al.*, 2007). Extracts from these mushrooms form components of various products in the nutraceutical industry.

Can small-scale oyster mushroom production be one of the poverty eradication packages in Botswana?

According to World Bank (2015) poverty in Botswana declined from 30% during 2002-2010 to 19.4% in 2015 and is expected to drop to 12% by 2018. The Bank recommends among others, boosting productivity, employment and labour-market efficiency. Eradication of poverty is a priority of the Botswana Government and in 2012 the Poverty Eradication Guidelines - Implementation of Packages 2012 was launched (Government of Botswana, 2012). Some of the packages included backyard gardening, bee-keeping, poultry, small stock and backyard tree nurseries. The government provided funds and materials to selected vulnerable individuals to assist them run these small businesses in order to generate family income. Some of these have been successful while others such as backyard gardening have faced challenges due to water scarcity. The cultivation of oyster mushroom is a potential alternative source of income and employment, food production and the improvement of nutritional status for the rural poor especially women and the youth in Botswana. The thrust of the current research project is to assess the current uses of crop residues and determine the potential additional income that can be realised when mushrooms are grown on the residues before they are fed to small stock.

Conclusion

Grain yields from rain-fed cereal production in Botswana continue to decline due to climate change-induced droughts. This is adversely affecting efforts to increase food security and reduce abject poverty among the rural poor not only in Botswana but the Southern African Development Community (SADC) region as a whole. Equipped with proper skills in oyster mushroom production small-scale farmers can engage in meaningful off-season economic activity by using their crop residues to produce high-value and

nutritious mushrooms as a way of adapting to climate.

Acknowledgment

This project is funded by The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) under the Competitive Grants System (No. RU 2015 GRG133). This paper is the project's contribution to the 2016 Fifth RUFORUM Biennial Conference and African Higher Education Week, held at Century City Conference Centre, Cape Town, South Africa, 15-21 October 2016.

References

- Akinfemi, A. 2012. Chemical composition and nutritive value of fungal treated acha straw. *Agricultural Science and Technology* 4: 120-124.
- Akinfemi, A., Jonathan, S. G. and Adu, O. A. 2010. Improving the nutritive value of millet stover using biological treatment. *Libyan Agriculture Research Center Journal International* 1 (3): 195-201.
- Akinfemi, A., Babayemi, O. J. and Jonathan, S. G. 2009. Bioconversion of maize husk into value added ruminant feed by using white-rot fungus. *Revista UDO Agrícola* 9 (4): 972-978.
- Alemu, F. 2014. Cultivation of *Pleurotus ostreatus* on Grevillea robusta leaves at Dilla University, Ethiopia. *Journal of Yeast and Fungal Research* 5(6): 74-83. DOI 105897/JYFR 2014.0139.
- Food and Agricultural Organisation (FAO), 2013. Climate Smart Agriculture Sourcebook, FAO, Rome.
- Government of Botswana, 2012. Poverty Eradication Guidelines Implementation Packages 2012. Gaborone, Botswana. (<http://www.gov.bw/Global/OP%20Ministry/Poverty%20Eradication%20Guidelines.pdf> 21 September 2016).
- Jongman, M., Khonga, E.B., Khare, K.B. and Mubyana, J. 2010. Effect of seasonal variation and supplementation on yield of oyster mushroom cultivation on indigenous grasses in Botswana. *Mushroom Research* 19 (2): 54-61.
- Khatun, K., Mahtab, H., Khanam, P.A. and Sayeed, M.A. 2007. Oyster mushroom reduce blood glucose and cholesterol in diabetic subjects. *Mymensingh Medical Journal* 16 (1): 94-99.
- Khonga, E.B. 2003. Highlights of oyster mushroom (*Pleurotus* spp.) production research in Botswana. *UNISWA Journal of Agriculture* 12:45-52.
- Khonga, E.B., Amarteifio, J. O. and Modise, D. 2005. The effect of substrate on yield and nutritional composition of oyster mushrooms (*Pleurotus* spp.) in Botswana. Proceedings of the second Crop Science and Production Conference, CICE, Botswana College of Agriculture, Botswana, 6-8 September 2005. 67-74 pp.
- Kossila, V. 1988. The availability of crop residues in developing countries in relation to livestock populations. In: Plant breeding and nutritive value of crop residues. Reed, J. D., Capper, B. S. and Neate, P. J. H. (Eds.). Proceedings of a Workshop

- held at ILCA, Addis Ababa, Ethiopia. ILCA Addis Abbaba 29-39 pp.
- Madibela, O. R. and Lekgari, L. A. 2005. The opportunities for enhancing the commercial value of sorghum in Botswana. *Journal of Food Technology* 3:331-335.
- Marshall, E. and Nair, N.G. 2009. Make money by growing mushrooms. FAO Diversification booklet number 7. FAO, Rome
- Ngezimana, W., Mtaita, T.A., Shoko, M. and Tagwira, M. 2008. Improving biological efficiency of oyster mushroom *Pleurotus ostreatus* FR (Polyporaceae) through composting and use of organic supplements. *International Journal of Biological and Chemical Sciences* 2 (1): 72-78.
- Obodai, M., Sawyerr, L. C. B. and Johnson, P. N. T. 2002. Yield of seven strains of oyster mushrooms (*Pleurotus* spp.) grown on composted sawdust of *Triplochiton scleroxylon*. *Tropical Science* 40 (2): 95–99.
- Oei, P. 1996. Mushroom cultivation. Tool Publications, Leiden, The Netherlands.
- Oei, P. 2003. Mushroom Cultivation-Appropriate Technology for Mushroom Growers (Third Edition). Backhuys Publishers, Leiden. Netherland.
- Poppe, J. 2004. Agricultural wastes as substrates for oyster mushroom. *Mushroom Grower's Handbook* 1: 75-85. MushWorld.
- Sarnklong, C., Cone, J. W., Pellikaan, W. and Hendriks, W. H. 2010. Utilization of rice straw and different treatments to improve its feed value for ruminants: A Review. *Asian-Australasian Journal of Animal Science* 23: 680-692.
- Shah, Z. A., Ashraf, M. and Ishtiaq, C.H. 2004. Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates: wheat straw, leaves, saw dust. *Pakistan Journal of Nutrition* 3: 158–160.
- Statistics Botswana, 2014. 2012 Annual Agricultural Survey Report. Statistics Botswana, Gaborone, Botswana. <http://www.cso.gov.bw> 21st September 2016
- Tasmin, K. 1988. Cultivation of mushrooms using crop residues as substrate. PhD thesis, University of the Punjab, Department of Botany, Lahore, India, eprints.hec.gov.pk/1490/1/1372.HTM
- World Bank, 2015. Botswana Poverty Assessment: Despite significant decline in poverty, many, nearly half of them children, are still poor. World Bank, Washington DC, USA. <http://www.worldbank.org/en/country/botswana/publication/botswana-poverty-assessment-december-2015>, 21st September 2016