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Intercropping as an effective component of integrated weed management in tropical root and tuber crops: A review

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ABSTRACT

Integrated weed management (IWM) strategies composed of non-chemical methods provide many beneficial effects to the agro-ecosystems, including growth and development of crops. The focus of this review is to explore the potential of intercropping as a non-chemical weed management technique in IWM in selected tropical root and tuber crops namely, sweet potato, yam, and cocoyam. Fast-growing and short-duration crops are suggested to be intercropped with root and tuber crops cautiously to achieve high intercrop productivity in such systems. Yam-pumpkin intercrop has reduced weed growth by 70% and increased the yield of component crops by 30–50% whereas sweet potato-maize-cocoyam intercrop has reported a 50–90% of yield depression in component crops in the absence of weed control measures. This signifies the importance of selecting a spatially and temporally compatible intercrop combination for weed control and higher yields of component crops in an intercrop. Sweet potato-maize-soybean system, sweet potato-peanut system, yam-fluted pumpkin/melon-okra/maize system and sun hemp-taro system have shown evidence to be compatible within each system and resulted in better weed control and higher crop yields. It is recommended to plant sweet potato at a density of 33,333 plants ha^{-1} with peanut at a density of 66,667 plants ha^{-1} for the lowest weed density and the highest yield advantage whereas ideal density levels of selected intercrops are yet to be researched in most of the intercropping systems with root and tuber crops. A limited number of researches have been successfully conducted to find out compatibility levels of intercrops focusing on the degree of weed management and yield advantage of sweet potato-, yam-, and cocoyam-based intercrops. Hence, further research is mandatory prior to endorsing intercropping as an effective weed management technique in root and tuber crops.

1. Introduction

Tropical root and tuber crops are considered as important sources of food and nutrition in many of the developing world's resource-poor farmers living in Africa and Asia, and, thus, considered as poor man's crops (Owusu-Darko et al., 2014; Scott, 2000). Among these, sweet potato (*Ipomoea batatas* L. Lam), yams (*Dioscorea* spp.), and edible aroids or cocoyams; taro (*Colocasia esculenta* L. Schott) and tannia (*Xanthosoma sagittifolium* L. Schott) have a significant potential in achieving food security in the tropics (Lebot, 2009; Owusu-Darko et al., 2014; Villordon et al., 2014), where sweet potato has been identified as one of the top 10 food crops in the world (Srinivas, 2009; Tavva and Nedunchezhiyan, 2012) (Table 1). Adaptation of these crops to resource-limited environments, their contribution to domestic food security, and suitability in most of the widespread intercropping systems make the tropical root and tuber crops an important component among the poor farming community (FAO, 2012; Horton, 1988; Labrada et al., 1994; Reddy, 2015; Tavva and Nedunchezhiyan, 2012). Moreover, commercial farmers also have shown their interest towards growing these crops at large scale due to their wide environmental flexibility, particularly under the consequences of climate change (Lebot, 2009; Reddy, 2015).

Weeds are considered as one of the major limitations in the production of root and tuber crops (Korieocha, 2014; Labrada et al., 1994; Lebot, 2009; Nedunchezhiyan et al., 2013). With the absence of comprehensive research on weed control in these crops, their production and productivity have been significantly affected (Lebot, 2009; Moody and Ezumah, 1974). The yield loss of sweet potato, yam, and cocoyam due to weed incidence can vary between

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Table 1
Production quantity, area harvested, and uses of sweet potato, yams, and cocoyam in 2014.

	Major producing countries[a]	Area harvested (ha)[a]	Production quantity (tons)[a]	Uses
Sweet potato	China	3,382,932	70,963,630	Food products, animal feed, industrial starch, thickeners, binders, taste and other culinary additives (Huang et al., 2003) non-food applications such as textiles, paper, adhesives, and pharmaceuticals (Fuglie and Oates, 2004)
	Nigeria	1,241,810	3,478,270	
	Tanzania	693,190	3,345,170	
	Ethiopia	59,398	2,701,599	
	Indonesia	156,677	2,382,658	
	Uganda	454,000	1,863,000	
	Vietnam	130,537	1,401,055	
	United States	54,710	1,341,910	
	India	105,870	1,087,880	
	Japan	38,000	886,500	
	Sri Lanka (Rank 48)	5542	50,304	
Yams	Nigeria	5,416,400	45,004,340	food vegetable, raw, boiled, baked or fried food products, 'fufu'(a stiff glutinous dough made in Africa), animal feed, industrial starch, colours, glue, pharmaceuticals (Chinwuba and Emmanuel, 2006)
	Ghana	428,000	7,119,000	
	Côte d'Ivoire	876,540	5,836,150	
	Benin	214,054	3,220,654	
	Ethiopia	48,817	1,448,835	
	Cameroon	56,100	578,840	
	Papua New Guinea	20,310	355,300	
	Brazil	25,700	247,000	
	Japan	7390	164,900	
	Philippines	2480	13,490	
Cocoyam (taro/Colocasia)	Nigeria	639,980	3,273,000	Boiled, roasted, fried food products, a leafy vegetable, 'fufu' (a pounded mass of boiled cocoyam in Africa), culinary additives, thickeners for baking and cooking soups such as 'oha' soup and 'bitter leaf' soup, porridge, chips, animal pharmaceuticals, industrial starch, processed baby foods, weaning diet, alcohol (Amadi et al., 2015; Owusu-Darko et al., 2014)
	China	96,510	1,868,590	
	Cameroon	170,540	1,637,900	
	Ghana	200,000	1,299,000	
	Papua New Guinea	35,090	272,770	
	Madagascar	37,800	234,820	
	Japan	13,300	166,000	
	Fiji	12,010	154,150	
	Egypt	3300	115,950	
	Philippines	15,850	114,800	
	Thailand	9390	97,540	
Cocoyam(Tannia/ Xanthosoma)	Cuba	16,720	269,590	
	Venezuela	7542	85,607	
	El Salvador	4860	41,110	
	Peru	5170	30,960	
	Costa Rica	2500	30,000	
	Mexico	209	8881	
	Panama	940	4680	

[a] http://www.factfish.com.

40 and 100%, depending on the type of crops, type of weeds, and weed density (Fadayomi, 1991; Iyagba, 2010). Hand weeding or any other cultural method is the most common weed control measure in these crops (Lebot, 2009; Nedunchezhiyan et al., 2013).

In areas with labour scarcity, chemical weed control has become the most effective alternative and it is expected to grow further in the future. However, use of herbicides is considered as a less common method of managing weeds in most of the crops including sweet potato, yams, and cocoyams (Hauser et al., 2015; Moody and Ezumah, 1974; Nedunchezhiyan et al., 2013; Silva et al., 2013). Comparatively low number of herbicides is recommended to control weeds in root and tuber crops compared to cereals, due to their low specificity, low availability, high cost, and phytotoxicity in comparison to cultural methods of weed control in those crops (Donald et al., 1991; Enyong et al., 2013; Melifonwu et al., 2000; Moyo et al., 2010). Moreover, negative effects of herbicides on soil microbial population and starch concentration in roots and tubers have been reported (Nedunchezhiyan et al., 2013). Thus, a single method of weed control is not proven to be completely successful in root and tuber crops. Accordingly, integrated weed management (IWM) have been proposed as a viable method for overcoming weed problem in many crops (Clarence and Stephan, 1991; Donald et al., 1991) including sweet potato, yam, and cocoyam and cassava (*Manihot esculenta* Crantz) (Akobundu, 1987; Iyagba, 2010). Cultural, biological, and the least possible level of cost-effective chemical methods are hence, suggested to be applied together in tropical root and tuber crops (Clarence and Stephan, 1991; Donald et al., 1991). Intercropping is being frequently used as a cultural technique of weed management in such instances (Akobundu, 1980; Iyagba, 2010; Melifonwu, 1994).

Intercropping has proven its ability to suppress weeds basically through two strategies. Intercrops may exert resource competition with weeds and may involve in allelopathic interactions, which are detrimental to the growth of weeds (Arora et al., 2015; Liebman and Dyck, 1993; Seran and Brintha, 2010). However, in some instances, the intercropping system by itself would not be able to provide a satisfactory level of weed control unless the best component crops are selected along with the best compatible environmental condition (Lithourgidis et al., 2011; Seran and Brintha, 2010). This article reviews the potential of intercropping to be used as a weed management technique either solely or in combination with other components of IWM in sweet potato, yam, and cocoyam. Moreover, related research is discussed focusing on the key factors that to be considered in designing root and tuber crops-based intercropping systems in the tropics to highlight the necessity of further investigations.

2. Sweet potato

2.1. Global status of sweet potato production

China is the world's leading sweet potato producing country

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