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Field measurement in vegetable crops indicates need for reevaluation of on-farm food loss estimates in North America

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ABSTRACT

Food loss and waste in the US has been estimated at 40%, a figure that does not include losses at the agricultural level. Consumer food waste is expensive and environmentally damaging as it travels the length of the supply chain and largely ends up in the landfill. Most research and campaigns emphasize the consumer level, which has resulted in the omission of data collection and development of solutions for producers of fruit and vegetable crops. The available estimates of edible produce lost in the field are based on assumptions and estimates, rather than field data. Therefore, this project aimed to measure losses in the field in order to understand if estimates are accurate. Sixty-eight fields of eight vegetable crops were evaluated on nine North Carolina farms during the 2017 production season, using a sampling and scaling method. Combining the unharvested crops of marketable quality and edible but not marketable quality (produce that does not meet appearance quality standards), the average produce volume available after the primary harvest was 5114.59 kg per hectare. Totaling an average of 42% of the marketed yield for these crops, these high figures indicate the need for a reevaluation of the food loss estimates at the agricultural level in the US, and a focus on solutions.

1. Introduction

The portion of the American food supply that is never eaten by consumers has been estimated at 40%, prompting national focus on the issue (Gunders, 2012; Gunders et al., 2017; Hall et al., 2009). This estimate subtracts the food consumed in the US from the total supply of food (Hall et al., 2009), and therefore would be larger if it included food that never reaches distribution: food lost at the stage of agricultural production. Globally, it is estimated that a reduction in food loss and waste of 50% in developed countries could lead to a reduction in the developing world's undernourished population by 63.3 million people (Munesue et al., 2015). The U.S. has now adopted this target, aiming to halve food waste by 2030, without specifically including losses at the farm level (USDA, 2015). Reducing food loss and waste could have far reaching impacts on the triple bottom line of environment, economy, and society in the U.S., and to that end, many solutions have been detailed (ReFED, 2016).

Food loss and waste results in a loss of resources including water, land, fuel, fertilizer, and agricultural chemicals that are either inefficiently used in agricultural production, or required during food processing and disposal (Hall et al., 2009; Kummu et al., 2012). An estimated 21% of water, 19% of fertilizer, and 18% of cropland is devoted to producing food that is not consumed in the U.S. (ReFED, 2016). “Food loss” is considered to be unintended and usually results from limitations in agricultural production such as market conditions or weather impacts on produce quality, while “food waste” is considered to be edible food that is unused as a result of a decision or negligence, and occurs in the distribution, restaurant, retail, and consumer levels of the supply chain (Lipinski et al., 2016).

Food loss and waste has been reported as an economic loss for the US, totaling $218 billion in 2016 when farm level estimates are included (ReFED, 2016), and a loss of over $165 billion in 2008 without including a farm-level estimate (Buzby and Hyman, 2012). In other sectors of the supply chain, an average benefit-cost ratio for investing in food waste reduction was determined to be 14:1, a significant financial incentive for businesses specializing in food manufacturing, retail, hospitality, and food service (Hanson and Mitchell, 2017). Detailing this ratio for agricultural producers first requires accurate assessments of losses. Twenty years ago, data on food loss in the U.S. was recognized as insufficient, and further investigation was suggested (Kantor et al.,

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1997). This idea continues to be echoed by government agencies: the Environmental Protection Agency (EPA), Natural Resources Defense Council (NRDC), National Science Foundation (NSF), and the United States Department of Agriculture (USDA) have all called for increased focus on the issue (Gunders, 2012; Gunders et al., 2017; NSF, 2014; USDA, 2015; EPA, 2015). Studies that estimate fruit and vegetable crops lost at the production level in the US through field sampling are significantly absent from Schnieder's (2013) thorough review of food waste research and Van der Werf and Gilliland's (2017) review because they are almost non-existent. Both reviews list studies that provide data on losses in agricultural production, but these use a calculation approach to determine estimates that are based on assumed or approximated percentages of loss not directly related to actual field estimates.

The most reliable estimate of agricultural losses of fruit and vegetable crops for North America has been provided by the Food and Agriculture Organization of the United Nations (FAO), suggesting 20% of the marketed yield of these crops remain unharvested in the field, or are sorted out during packing (Gustavsson et al., 2011), leading to the assumption that 10% of the marketed crop is left unharvested in the field, and 10% is lost during packing. This estimate carries forward figures based on approximations for pathogen-based losses from the 1960's (Cappellini and Ceponis, 1984; Golumbic, 1964; Harvey, 1978; Kader, 2005; LeClerg, 1964; Parfitt et al., 2010).

The need for more accurate estimates is necessary in order to determine the true environmental, economic, and societal costs of food loss and waste. However, as consumer-level food waste is assumed to represent the highest value contributor to food loss and waste in the supply chain, and because it may be easier to quantify than agricultural losses, emphasis has remained on consumer-related waste (Griffin et al., 2009; Gustavsson et al., 2011). Focusing on consumer-level waste has driven the development of interventions such as toolkits to reduce waste, software for tracking and utility, economic analysis, and a national consumer campaign. The US EPA has produced several guides to measure and reduce food waste at the distribution, retail, restaurant, and foodservice sections of the supply chain, in addition to a guide for schools and an overview for any food business (EPA, 2014, 2017, 2018). Other groups, such as the Food Waste Reduction Alliance have also created detailed guides for reducing losses and waste (FWRA, 2015; ReFED, 2018). The same types of tools could be utilized to reduce loss in agricultural production.

The omission of the farm level loss discussion in the US is further evidenced by reports and datasets that provide information on food loss and waste, yet are unable to report farm level loss due to a lack of data (Buzby and Hyman, 2012; Gunders, 2012; Hodges et al., 2011; Kantor et al., 1997). The US Department of Agriculture's Economic Research Service collects the most comprehensive data available on the US food supply, and their “Loss-Adjusted Food Availability” dataset omits available supply on the farm (Buzby et al., 2014). The USDA's National Agricultural Statistics Service comes closer to reporting on farm supply that is unutilized, reporting grower survey data on planted area that was not harvested in each year's vegetables annual summary (USDA-NASS, 2017). However, this data leaves out fields that have been harvested once or several times, but are still producing a viable crop that is subsequently destroyed.

Fruit and vegetable crops are lost at higher estimated rates than other food groups globally due to their perishable nature, and in developed countries are lost at the agricultural level at higher estimated rates than during postharvest, processing, distribution, and consumption (Gustavsson et al., 2011). At the agricultural level, produce is lost when it is left unharvested in the field, or sorted out during washing and packing. Some of this loss is due to damaged, diseased, or overmature produce. A portion of the food lost is edible, as many variables need to coalesce in order to bring product to market, including price, buyer availability, and quality. Produce recovery from farms can be straightforward, however, as it requires no change to the harvesting, marketing and handling systems in place, and uses current labor structures. Additionally, fresh produce has the potential to be a more recoverable food group than meat, dairy, and grains, as it requires little or no processing before distribution (Garrone et al., 2014). A recent report from a collaborative focused on reducing food loss and waste has provided a volume estimate, suggesting that 9.2 billion kg of produce remains on the farm in the U.S., basing this figure on interview estimates from small farms and national data on planted acreage that was not harvested (ReFED, 2016; Berkenkamp and Nennich, 2015; USDA-NASS, 2017).

Field measurement of unharvested crops has been used as a strategy to estimate losses in a few studies in Europe, and a replicable sampling method adaptable to a wide variety of crops has now been described for US production (Johnson, 2018; Johnson et al., 2018). As underreporting is a common problem when using grower estimates (Franke et al., 2016; WRAP, 2017), field sampling provides systematic evidence of the quantity and quality of crops left unharvested in the field, and is considered vital when losses are not known (Franke et al., 2016). In US studies, grower estimates and not field sampling have been used to determine losses in the field. Berkenkamp and Nennich (2015) reported that most cabbage growers and nearly half of summer squash growers surveyed estimated the rate of cosmetic imperfection found in these crops was between one and 10%. Snow and Dean (2016) reported that small, diversified farms in Vermont leave just 5% of edible vegetables unharvested in the field. Estimated head lettuce left in the field according to grower interviews on large commercial farms in California was reported as 4–10% (Milepost, 2012).

This project aimed to determine if the current food loss estimates available would change if they were supported by data, using field sampling to quantify edible vegetable crops at the production level in the US. The focus of this study is on medium to large-scale production in the southeastern region. The first step in understanding the true cost of food loss at the farm level in the U.S. hinges on accurate estimation of the volumes of losses.

2. Materials and methods

This section provides a condensed version of the method used by the author to harvest and evaluate field samples of eight different crops, which were then used to estimate the produce remaining per acre in the field after the grower determined their harvest was complete (Johnson, 2018; Johnson et al., 2018). The reporting includes several elements in order to be in compliance with the Food Loss and Waste Accounting and Reporting Standard (Lipinski et al., 2016), which are described here. The material collected was food and its associated inedible parts, such as watermelon rind, or cabbage and pepper stems and cores. The produce was destined to be sold unprocessed and intended for the fresh market, conforming to the definition of the fresh vegetable category [GSFA 04.2.1.2] (FAO-WHO, 2016). “Growing of vegetables and melons, roots and tubers” represents the correct International Standard Industrial Classification of All Economic Activities Rev. 4 code 0113 that corresponds to the life cycle stage of the produce (UNSTATS, 2017). Samples were harvested and evaluated entirely in North Carolina, USA, in 2017. Losses reported here were left unharvested by the producer and after measurement, were either incorporated into the soil or destroyed in order to plant another crop, as the final disposition intended by the grower. Measurements did not include water or packaging, and pre-harvest losses such as losses of plants due to insect or disease damage were not considered.

A total of 68 fields of eight vegetable crops were evaluated on nine commercial farms in eastern North Carolina, an important production region in the state. Farm identification began two years prior, through the use of a survey instrument which opened discussion on the topic of farm surplus with vegetable growers at commodity meetings. Growers interested in further discussion were invited to participate in an on-farm interview, and about half of the growers interviewed provided access to fields during the growing season for field measurement.