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For Nutrition, Carbon Sequestration, and Biodiversity, Perennial Vegetables are a Neglected Resource

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Abstract

Perennial vegetables are a neglected and underutilized class of crops with potential to address 21st century challenges. They represent 33–56% of cultivated vegetable species, and occupy 6% of world vegetable cropland. Despite their distinct relevance to climate change mitigation and nutritional security, perennial vegetables receive little attention in the scientific literature. Compared to widely grown and marketed vegetable crops, many perennial vegetables show higher levels of key nutrients needed to address deficiencies. Trees with edible leaves are the group of vegetables with the highest levels of these key nutrients. Individual "multi-nutrient" species are identified with very high levels of multiple nutrients for addressing deficiencies [1]. This paper reports on the synthesis and meta-analysis of a heretofore fragmented global literature on 613 cultivated perennial vegetables, representing 107 botanical families from every inhabited continent, in order to characterize the extent and potential of this class of crops. Carbon sequestration potential from new adoption of perennial vegetables is estimated at 22.7–280.6 MMT CO_2-eq/yr on 4.6–26.4 Mha by 2050.

Keywords: Health; Nutrients; Phytochemicals; Shelf-life; Vegetables; Nutrition; Vegetables

Introduction

Large loads of silt and nutrients, which are mostly the result of anthropogenic activity, are a global problem for streams and rivers. Industrial forestry and agriculture-related soil erosion and over fertilization increase the loads of sediment and nutrients in river systems, which lead to eutrophication and siltation. Additionally, hydro-engineering infrastructure frequently obstructs the river's sediment transport process. The crucial ecosystem function of sediment and nutrient retention is, however, provided by river floodplains, which can act as a sink for sediment and its associated nutrients by holding these during floods [2].

Natural floodplains limit the amount of sediment and nutrients that are carried downstream during flooding. A significant portion of the yearly riverine sediment and nutrient load can be retained in floodplains, particularly in hydrologically coupled systems. The amount rises as the extent and duration of the flood do. Additionally, according to projections, the depth of the flooding will enhance the roughness of the floodplain, which could lead to more sedimentation there. The accumulating nutrients may increase the productivity of the vegetation in the floodplain [3]. However, anthropogenic activities such as channelization, embankments, bank stabilization, and river straightening have significantly reduced floodplain areas. As a result, floodplains are an endangered environment throughout the world. As a result, attempts to restore floodplains have grown during the past few decades. Many nations launched initiatives that focused on reconnecting rivers and floodplains to restore natural conditions and protect against flooding. Additionally, it is anticipated that reconnection efforts will affect floodplains' ability to retain water, but their underlying causes still need to be better taken into account when managing and restoring rivers and floodplains [4]. However, in order to manage floodplains for the best sediment and nutrient retention, it is important to comprehend how vegetation structure, plant community composition, and diversity affect sedimentation and how these biotic drivers interact with hydromorphological control.

The flood and other biogeomorphic processes in the floodplain are both important factors in the complicated phenomena of sediment retention. While the geography of the floodplain primarily affects the deposition of coarse sediment, the plant type and structure that affect fluvial processes and sediment transport are particularly pertinent for the deposition of finer particle sizes. Reed beds deposited more nitrogen and phosphorus than grass or woodlands, and communities of herbaceous vegetation were more effective at accumulating fine sediment than shrub lands and floodplain forests. In a prior study, we demonstrated that the structural properties of the community (biomass, density, height, structural diversity, and leaf pubescence) increase sedimentation in a flume experiment when the environment is controlled [5]. This study, however, is the first to look into in situ measurements of an actual flood event by concentrating on sedimentation within the vegetation, separating the process of sedimentation on vegetation from the process of sedimentation underneath the vegetation, looking into the role of species diversity, leaf surface structure, and community structure, and combining these vegetation characteristics with topographical parameters of the floodplain.

It is well known that certain structural features of the vegetation often assessed surrounding (in front of and behind) vegetation patches, affect a floodplain's ability to retain silt. The flume studies for sedimentation on the vegetation and partially also underneath the vegetation indicated that biomass enhances sediment retention in general. It has been proposed that dense floodplain vegetation is highly effective at accumulating fine silt. As a result, sediment can

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sink and accumulate since the flow velocity is decreased. Since altering plant height causes turbulence and may locally raise and reduce flow velocities, it is possible that this change in vegetation height will also have an effect on sedimentation. Height variation and sedimentation on the vegetation were found to have a negative relationship in the flume experiment. It was discovered that the height of herbaceous floodplain vegetation controls the deposition of finer sediment (silt and clay) [6].

Hotspots of biodiversity include floodplain meadows and riparian zones. They are also one of the most endangered environments in the world. Even though it is known to affect other ecosystem functions like productivity and nutrient dynamics, species diversity per se is rarely researched in the context of sediment retention on floodplains. In the absence of identity effects, the results of the flume experiment only provided evidence for the effects of species richness on sedimentation. The structural diversity of vegetation has been found to correlate with species diversity, and this was found to increase sedimentation. Diversified grasslands exploit the growth area in a complimentary way, which results in a higher density and taller height than less diverse grasslands, according to dedicated biodiversity tests. Although we directly account for these two factors, there might be other effects that go beyond the average characteristics of the vegetation. For example, combining tall/sparse with small/dense plant species may be especially successful at retaining sediment. Regardless of total density or stature, the trait combination may increase overall sedimentation. When comparing monocultures with a three-species mixture in an experiment, no discernible effects of the species diversity of herbaceous vegetation on sediment retention were found in front of and behind a vegetation patch. A different picture might emerge from the study of a longer diversity gradient in the field, though [7].

In addition to vegetation structure, the vegetation's leaf surface structure affects sedimentation. Particularly, it has been demonstrated that leaf pubescence positively influences sediment retention at the level of herbaceous leaf surfaces while leaf area on unhaired leaves negatively influences it. As a result, studies on sedimentation in herbaceous vegetation have rarely taken into account the mean expression of these traits in the vegetation, which may also be significant for sedimentation at the level of floodplain vegetation patches.

The primary abiotic elements that could explain silt dispersal within the floodplain are topographic characteristics. Elevation has a significant impact on discharge, and with it, inundation depth, hence the placement inside the floodplain is important for sedimentation. Compared to coarse sediment, fine silt is transported further along rivers and into floodplains, and it only settles in places with slower flow rates. In general, it was discovered that as the distance from the river increased, sedimentation decreased [8]. The topographic diversity of a dynamic riverine floodplain and the winding path the water takes into the floodplain during floods are not necessarily represented by a straight line, though. Therefore, a better technique to gauge how river water moves from the river into the floodplain during floods is to estimate the length of the shortest path with the lowest elevation. The topography of the floodplain may therefore be more accurately represented by such a measurement for the genuine "hydrological distance." Other names for the same measure, such as the flow path or the hydrological connectivity, were used in some studies.

Materials and Methods

Selection and collection of material

Samples of apples, mangoes, bottle gourds, and ridge gourds were gathered from Lahore's local market (31.5204° N, 74.3587° E). Samples were delivered to the lab in polythene bags, sealed, and kept there at 4°C pending analysis. A random sampling technique was used to collect samples [9].

Preparation of peels powder

From the neighborhood market in Lahore (31.5204° N, 74.3587° E), samples of apples, mangoes, bottle gourds, and ridge gourds were collected. In polythene bags, samples were brought to the lab, sealed, and maintained there at 4°C pending analysis. To gather samples, a random sampling method was employed.

Extraction of peels: preparation

The process was used to prepare the peels of the fruits and vegetables. 20 ml of 80% methanol and 80 ml of distilled water were used to extract a total of 2 g of each fruit and vegetable peel. The combination was centrifuged at 3000 rpm for 10 minutes, and the supernatant that emerged was gathered for additional research. Qualitative analysis of antioxidant activity by DPPH assay [10].

Utilizing 1, 1-diphyenyl, 2-picrylhydrazyl, the qualitative antioxidant activity was measured (DPPH). 100 l of 0.1% methanol, 50 l of test sample, and 50 l of DPPH were added to a micro-Petri dish. The mixture was incubated in the dark for 30 minutes. Following incubation, the test sample's color transformation from purple to yellow or light pink was visually assessed. The stable free 1, 1-diphenyl-2-picrylhydrazyl radical was converted into the yellow 2, 2-diphenyl-1-picrylhydrazyl by reaction with an antioxidant.

Determination of total phenolic content

Total phenolic content (TPC) was assessed using the Folin-Ciocalteu (FC) method with a few minor adjustments to assess the antioxidant capacity of fruit and vegetable peels. In a nutshell, 0.1 ml of obtained extract was combined with 0.5 ml of 10% Folin reagent. The mixture was then thoroughly mixed, swirled, and let to stand for about 6 minutes before the addition of 1 ml of 7.5% Na2CO3. The solutions might then rest at room temperature for two hours. After incubation, an UV/Vis spectrophotometer made by Shimadzu-Japan was used to measure the absorbance at 765 nm. Gallic acid was used as the standard, with concentrations ranging from 100 to 1000 mg/ml, to obtain the calibration curve. Gallic acid equivalent (GAE) per gramme of dry sample was used to express the TPC results in relation to the gallic acid standard curve (R2 = 0.900). Averaging was done after triplicate analyses of each sample [11].

Statistical analysis

Software called Statistica was used to calculate the descriptive statistics. Using Minitab version 17, correlations between antioxidant activity and total phenolic content were found between samples of fruit and vegetable extracts. Statistica software used a one-way ANOVA and a t-test.

Discussion

With the help of this investigation, we were able to separate in-situ measurements of sedimentation from vegetation on and beneath a floodplain, assessing its relative importance in respect to topographic causes. While vegetation parameters did not explain sedimentation beneath the vegetation, biomass and height variation increased sedimentation on the vegetation. An important factor in understanding the retention of silt and nutrients on and beneath the vegetation was the hydrological distance. Despite the amount of sediment decreasing with increasing hydrological distance from the river, carbon, nitrogen, and phosphorus on the vegetation increased. We were unable to find any proof that the amount of sediment and nutrient retention is influenced by species diversity or leaf surface structure [12].

The three floodplains of one river were the subject of the current investigation. 24 locations were flooded, making them available for the analysis, despite the flood's low amplitude and high frequency (biannual). The results' explanatory power demonstrates the factors' broader significance in the processes leading to floodplain sedimentation.

Conclusion

A particularly significant and underutilized type of crops is perennial vegetables. In addition to addressing the nutrient inadequacies that plague more than 2 billion people, they have the potential to boost carbon sequestration in vegetable cultivation. To address some of the major problems of the twenty-first century, they provide an essential set of instruments.

With a few exceptions, this study discovered that the veggies that are most often grown and sold are not ones that are most able to alleviate vitamin deficits. In order to ensure that everyone has access to a healthy diet, the world's vegetable production must be tripled. Therefore, efforts should be made to include PVs in the new production regions.

The fact that tree vegetables are among the healthiest, have high sequestration rates, and make up more than a quarter of PV species is very welcome news. The fact that there are numerous species of tree vegetables for colder climes, including cold drylands, shows that they are not just found in the tropics.

The discovery of species with high concentrations of certain essential nutrients presents an opportunity to promote these crops in development and nutrition programmes. Regional programmes could find species that are adapted to the local environment and focused on the population's particular nutrient requirements. The species native to a particular region can be given priority because PVs are widely distributed.

In order to boost soil carbon sequestration and perennial biomass, perennial vegetables can help perennialize agriculture. Given the high rates of carbon sequestration in agroforestry systems, their potential for application in these systems is noteworthy. This is true especially given the abundance of shade-tolerant PV species. Be aware that some PVs sequester significantly more carbon than others, particularly large woody plants like trees, palms, and bamboo.

Acknowledgement

None

Conflict of Interest

None

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