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Soluble Elements Released from Organic Wastes to Increase Available Nutrients for Soil and Crops

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Abstract: Member States of the European Union must ban burning arable stubble by 2023 and improve the recycling of organic waste into fertilizers and organic farming practices by 2030. The current lack of nutrients from soils and crops leads to food insecurity, human malnutrition and diseases. Consequently, innovative solutions are required, as technosols are constructed by waste. The objective of this paper is to educate on the nutrients that some pruning residues can provide. This work characterizes elemental composition, nutrients soluble fraction and physical and chemical properties of the following organic wastes: almond tree pruning, commercial peat substrate, olive tree pruning, pine needle, date palm leaf pruning, sewage sludge compost and vine pruning. The results show significant differences between macro (Na, K, Ca, Mg) and micronutrient (Fe, Mn, Cu, Zn) content and their solubility. Sewage sludge compost, olive pruning and pine needle are the three residues with the highest presence of nutrients in their elemental composition. Nevertheless, if a farmer applies pruning residues as a nutritional supplement for crops, it will be key to finding the short-term soluble nutrient rate and synchronizing the nutritional requirement curve of a plant's life cycle with its nutrient release. Consequently, organic waste (without composting treatment) obtains higher solubility rates, being date palm leaf residue the one with the greatest value. The solubility index of organic wastes can be significant in providing short-term nutrients to crops. Hence, our results can help in choosing the proper waste to enhance plant nutrient supply, mainly K, Ca, Mg and Na for crop nutrition, to ensure efficient biofertilization.

Keywords: circular economy; organic matter; pH; soil amendment; SGDs

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1. Introduction

The growing world population is expected to increase to 9.8 billion by 2050 [1], and occupation of land with superior agricultural potential for the expansion of cities will intensify pressure on the agricultural capacity to meet resulting agri-food demand [2,3]. With the intention of reducing the environmental impacts of agricultural systems, sustainable agriculture is postulated as an option that is increasingly widespread and demanded by consumers since it is also linked to health prevention. The FAO [4] defined sustainable agricultural development as "the management and conservation of the natural resource base, and the orientation of technological change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Sustainable agriculture conserves land, water, and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable". It is well known that although 95% of our food originates from the soil, it is a non-renewable resource, and food production is at risk. Fertile agricultural soil is decreasing yearly, so it is estimated to be depleted in 60 years [5].

One of the main pillars of sustainable agriculture is sustainable soil management since its quality and health are decisive for agricultural production, human nutrition and health, and agricultural ecosystem biodiversity [5,6]. The FAO [7] considers soil management sustainable "if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. The balance between the supporting and provisioning services for plant production and the regulating services the soil provides for water quality and availability and for atmospheric greenhouse gas composition is a particular concern". The main challenges highlighted by the FAO [7] for sustainable soil management to ensure the provision of ecosystem services are minimizing soil erosion, enhancing soil organic matter content, fostering soil nutrient balance and cycles, preventing, minimizing and mitigating soil salinization, alkalization and acidification, preserving and enhancing soil biodiversity, improving soil water management and preventing and mitigating soil compaction and soil sealing restoration. To face them, the FAO [7] proposes several options, but there is only one that is common to all these problems: soil cover with organic residues such as mulching or organic amendments, although it suggests preventing soil contamination by ensuring the safety of organic residues applied to the soil. Accordingly, El Chami et al. [6] indicated that sustainable agricultural practices are mostly related to the use of organic soil amendments and mulching. This is supported by Rabary et al. [8], who showed that no-tillage and permanent soil cover are key factors for improving soil properties. What is more, the use of organic and crop residues above ground is a valid option to increase the biodiversity of the agricultural ecosystem [9], CO_2 storage [8,10] and to improve nutrient supply [10–13] and human nutrition [5] and its application as a substrate is also considered for crop nutrient supply [10,14–17]. Its use to formulate suitable soil for agricultural production is one of the possible applications that have not been studied enough [18], especially from the point of view of the nutrient source.

Huge amounts of organic residues associated with agri-food production are generated annually. Currently, the European agricultural system generates about 700 million tons of agri-food waste, and it is estimated that between 10 to 12% of global emissions are associated with agricultural production [19]. This represents a challenge and an opportunity for environmentally and economically sustainable management of agricultural holdings to continue advancing in the use of its wastes according to principles of the circular economy [10,19]. Each type of agricultural production involves co-products, by-products and specific residues. Notwithstanding, one activity that is common to all farms is pruning. The resulting material is included in the category of waste since their production does not entail an economic benefit, even implying an expense associated with their management. Burning is a widespread practice for pruning remains management, which implies fire hazard [20], emission of greenhouse gases into the atmosphere, assuming a reduction in carbon sequestration, as well as loss of elements and nutrients that compose them [13,21]. Moreover, the Member States of the European Union have to ban burning arable stubble by 2023 in order to preserve the organic matter of soil [22]. Consequently, farmers need to know the nutrients that their pruning residues can provide to crops to match them with the plant's requirements.

Nevertheless, biowaste application to improve productivity and fertility of agricultural soils has been a common practice used since immemorial time, lately overshadowed by inorganic fertilizer [23]. Currently, Farm to Fork UE Strategy aims to recycle organic waste into renewable fertilizer and increase organic farming by 2030 [24]. Organic residues have a great advantage over chemical fertilizers since they can improve the physical properties of soil and microbial activity, functionality and ecosystem services [14,25–27]. In addition, by choosing the best management practices based on their possible nutrient contribution, the rate of chemical fertilizers could be reduced or eliminated [23], with its consequent benefit for the health of ecosystems and people [28]. In fact, Zipori et al. [16] consider that the rate of inorganic fertilizer added is usually higher than necessary.

Against this background, due to it being essential for humans, animals and plant health, and the impossibility, for example, of synthesizing trace elements [29], new options are emerging for the use of pruning and crop residues, such as obtaining biochemical and enzymatic compounds, recycling bioplastics, civil engineering or energy [30–32]. Furthermore, an alternative use, since it allows the direct reincorporation of nutrients and elements into natural cycles and which does not require an industrial transformation process, is the soil application as mulching or as part of a functional substrate called technosols [33,34]. Therefore, dysfunctional, contaminated or not fertile soil may require it to stimulate microbial activity and soil properties [8,25,26] and to ensure food security [25,27,29]. To prepare anthropogenic soils, it is necessary to know their components, specifically those that will constitute the organic fraction and present hazardous substances.

Malnutrition is, globally and, more specifically, in developing countries, an essential issue that affects a number of people, and it continues to rise. After remaining almost unchanged from 2014 to 2019, in 2020, between 720 and 811 million people worldwide suffered from hunger, 161 million more than in 2019. It is possible that effects of the COVID-19 pandemic have had an impact on this issue, which complicates the challenge of meeting the goal of zero hunger from Sustainable Development Goals (SGDs) by 2030 [35]. Asia and Africa are the most affected continents [35]; in addition, they usually have poorly fertile soils, as many international aid programs show. Therefore, affordable, sustainable and manageable practices that provide nutrients are required in these areas [13]. As we know, an adequate human diet implies the incorporation of at least 25 mineral elements, whose food reservoir is mainly through plants [36]. Plants are composed of 20 basic elements: C, H, O, N, P, K, Ca, Mg, S, Fe, Mn, B, Mo, Cu, Zn, Cl, Na, Si, Co, and Ni that are provided from soil solution (except for C and O) [37]. Thirteen of these elements (N, P, K, Ca, Mg, S, Fe, Mn, B, Mo, Cu, Zn, and Cl), apart from oxygen, carbon and hydrogen, are considered essential for the growth of all crops [28,38]. In addition, Na, Se, Co, Al, Ni and Si are beneficial for plant growth and Na, Se, and Co are essential for mammals [29]. White and Broadley [39] consider Fe, Zn, I, Se, Ca, Mg and Cu the mineral elements that are most lacking in human nutrition. In addition, worldwide, over 2 billion people are suffering from micronutrient deficiencies, and over the last 70 years, nutrients and vitamins in food have drastically decreased [5]. It also happens in developing countries due to over-cultivation on soils with reduced phyto-availability of essential elements to human nutrition.

The release of nutrients in soil occurs from the solubilization of the parent rock or sediments and from the mineralization of organic matter. To benefit crop yield, the soil nutrients available and absorbed by plants must be presented in soluble forms in the soil solution [36]. The speed of waste decomposition and nutrient release is important for sustainable crop management practices, mainly influenced by climatic conditions (temperature and humidity), soil quality (properties, microbiological activity and aeration rate), residue composition (for instance: biochemical composition, nutrient concentration and type of structure: lignified or not), and the application method (more or less direct contact of residue with soil, above or underground), as well as recycling treatment (drying, composting, pyrolysis among others), and residue size and storage method [11,13,20,23,27,40,41]. Moreover, Zipori et al. [16] found that seasonality (in which residues are applied) is important, especially in Mediterranean climates, to take advantage of the leaching effect of nutrients from rainfall at the end of winter and spring.

The decomposition of organic matter occurs in two phases, an initial one characterized by the washing of soluble compounds and nutrients and by decomposing of labile materials (sugars, phenols, starch and protein), followed by decomposing of recalcitrant materials (cellulose, hemicellulose, tannins and lignin) [20,42]. Although Hossain et al. [25] highlight the importance of organic residues to increase crop productivity, the bioavailability of micronutrients in soil, as well as macronutrients absorption by plants, Foereid [41] contemplates that not all nutrients in biofertilizers are immediately available, nor when they can become so. This initial contribution of soluble elements has been scarcer studied [23,43,44] since most references related to nutrients of residues focus on the decomposition of labile or recalcitrant matter.

The objective of this research is to assess physical and chemical properties and nutrient solubility from several organic residues. From each organic waste, elemental composition and aqueous extractable content were studied related to needed nutrients for people and plants (Na, K, Ca, Mg, Fe, Mn, Cu and Zn). Therefore, we deal with a first approximation of the waste potential for formulating technosols considering nutrient supply. Knowing short-term soluble nutrients from pruning residues allows farmers to add the residues to the soil under the nutritional request of their crops.

2. Materials and Methods

2.1. Selected Residues

Based on its availability (proximity to consider circular economy and zero waste strategy) and potentiality to be part of technosols, the following organic residues were selected:

- Almond tree pruning (AP)
- Commercial brown peat (CP)
- Olive tree (*Olea europaea* L.) pruning (OP)
- Pine (*Pinus halepensis*) needle fall (PN)
- Date palm (*Phoenix dactylifera* L.) leaf pruning (PP)
- Sewage sludge compost (SC)
- Vine (*Vitis vinifera*) pruning (VP)

Pruning and harvesting residues (AP, OP, PN, PP and VP) were collected from agricultural areas close to Elche (Alicante, Spain). SC was processed and obtained from Aspe Wastewater Treatment Plant (Alicante, Spain). PP was subjected to an initial shred after pruning, and PN was collected directly from the ground surface in the closest *Pinus halepensis* forest area.

2.2. Residue Characterization and Methods

All residues were subjected to conditioning processes consisting of air drying at room temperature inside a greenhouse (reaching temperatures over 40 °C), shredded and sieved (2 mm). Residue characterization consisted of the analysis of bulk density (ρ_b), organic matter content (OM), moisture content (MC) and elemental composition. ρ_b was calculated volumetrically as a ratio between residue mass and volume by using the cylinder method. An LED digital drying and sterilization oven (J.P. SELECTA®, Conterm 2000253, Barcelona, Spain) was needed to get MC and OM (UNE-EN 13040) [45]. Biowaste samples were dried at 103 °C until the difference between two successive weightings was less than 0.1 g for MC and 0.01 g for OM. The determination of organic matter (OM), expressed as a percentage by weight of dry matter, also required a muffle (Nabertherm, controller P320) and was determined by loss on ignition at a temperature of 450 °C until the difference between two successive weightings is less than 0.01 g (UNE-EN 13039) [46].

Elemental composition was determined by atomic absorption spectrometer (AAS) (Thermo Scientific, iCE 3000 Series AA Spectrometer) after acid digestion (69% nitric acid + H_2O_2) of samples (0.2 g) in a microwave. AAS is calibrated before use by testing the absorbance with solutions of quantitative certificated standards. Instrumental parameters are listed in Table 1.

The aqueous extraction of nutrients (1:10 w/v) of each residue was obtained by using 100 mL of deionized water added to 10 g of residue and shaking for 2 h. After filtering, the pH was measured by using a CRISON GLP 21 pH meter, electrical conductivity (EC) with a CRISON GLP 31 conductivity meter, and macro (Na, K, Ca, Mg) and micronutrients (Fe, Mn, Cu, Zn) composition with an AAS (Thermo Scientific, iCE 3000 Series AA Spectrometer).

Table 1. AAS instrumental parameters.

Parameter	Na	K	Ca	Mg	Fe	Mn	Cu	Zn
Wavelength (nm)	589.0	766.5	422.7	285.2	248.3	279.5	324.8	213.9
Bandpass (nm)	0.5	0.5	0.5	0.5	0.2	0.2	0.5	0.5
Lamp current (mA)	max. 8	max. 8	max. 10	max. 4	max. 15	max. 12	max. 5	max. 10
Atomization mode	emission		absorption					
Flame type	air/acetylene							
Fuel flow rate (l min^{-1})	1.1	1.1	1.4	1.1	0.9	1.0	1.1	1.2
Detection limits (mg l^{-1})	0.005	0.010	0.08	0.005	0.06	0.03	0.04	0.01

Additionally, nutrient solubility index (I_N) was calculated as the percentage of nutrients extracted in aqueous solution with respect to elemental composition in each residue, both expressed in dry weight basis, according to Equation (1) [43]:

$$I_N = (W_N/C_N) \times 100 \quad (1)$$

$_N$: macro or micronutrient; W_N: water extractable nutrient content; C_N: elemental composition nutrient content.

2.3. Statistical Analysis

Descriptive statistics were used to calculate the mean and standard deviation for each individual analysis of residues (five repetitions per each one). Analysis of variance (ANOVA) and Tukey's multiple comparisons test were conducted using SPSS Statistics (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY, USA: IBM Corp).

3. Results and Discussion

The data found in the references about the production of the selected organic wastes in other Mediterranean regions provide us with interesting information on the amounts of waste produced. Our findings may be useful for them because European countries are asked to avoid burning pruning residues in 2023, and other countries may follow too. As well as for meeting circular economy.

Date palm (*Phoenix dactylifera* L.) is grown mostly in the Middle East and North Africa [47,48]. In southern Europe, it is also presented in the palm grove of Elche (Alicante, Spain), which is the largest on this continent (507.4 ha) and is recognized as a World Heritage by UNESCO [32]. Each date palm produces between 10–20 leaves and 20 kg of dry leaves per year [49,50], and despite the variety of ancestral uses of the different parts of a palm tree, the use of leaves as a soil amendment or substrate has not been studied in European soils in depth. However, in Middle Eastern and North African countries, there are references that tested its usefulness as a biofertilizer or substrate after composting [51–53] and Ahmed and Al-Dousari [49] successfully used whole palm leaves as mulching to recover degraded areas in Kuwait.

The FAO [54] considers that Spain produced 6,817,770 tons of grapes and 8,137,810 tons of olives in 2020. There is a scarce number of references that deal with the use of a substrate for the harvest benefit of vine pruning, and an example is Yilmaz et al. [40]. In this work carried out by Repullo et al. [20], they obtained 42.3 kg of fine pruning residues and 17.9 kg of thick residues per tree, with an average pruning of 10 olive trees (previous pruning was performed three years prior). In the Andalusian region (Spain), olive pruning residues account for between 1.95 and 4.5 million tons per year [21]. Studies have been carried out to verify shredded pruning olive tree residue's contribution to olive groves. Gomez-Muñoz et al. [21] concluded that soil benefits more if residues are provided without burning (greater carbon sequestration, increase in organic matter and reduction of erosion). Zipori et al. [16] state that the use of olive tree pruning is a sustainable practice to improve plant nutrition.

In 2020, more than 4 million tons of almonds with shells were produced worldwide [54], with Spain being the second largest producer. This means that almond pruning is available in many areas as a soil amendment. *Pinus halepensis* is widely distributed in Mediterranean climate areas, and needle fall production measured in Spain was between 2080 and 2218 kg ha^{-1} $year^{-1}$ [55]. We have found various references that prove that needle fall contribution to soil nutrition has been carried out previously [55–57]. Sewage sludge is a by-product obtained from the treatment of urban wastewater. In Spain, around 1,200,000 dry matter tons are produced annually, mainly used for agricultural purposes (80%) due to their high nutrient content [58]. Sludges require stabilizing treatments to reduce water content and pathogens and to ensure organic matter stability; composting is one of the most applied processes.

3.1. Physical and Chemical Characteristics of Wastes

It is important to ensure that nutrients released during decomposition are synchronized with the crop nutrient requirement curve [23]. Therefore, studies on the possibility of applying organic wastes to soil to take advantage of its nutrients must begin with an analysis of its physical and chemical properties and elemental composition. The results obtained for the selected waste are presented in Table 2.

Table 2. Bulk density (ρ_b), OM, MC, pH and EC of each residue, average ($\bar{x}$) and standard deviation (σ).

Residue	ρ_b (g cm^{-3})		OM (%)		MC (%)		pH (units)		EC (µS cm^{-1})	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
AP	0.36 a	0.006	93.2 b	0.6	8.0 b	0.03	4.66 a	0.007	665 b	0.8
CP	0.37 a	0.004	91.0 a	0.9	52.7 c	0.41	5.02 b	0.031	1447 a	3.1
OP	0.40 b	0.003	94.1 b	0.1	6.3 d	0.21	4.78 c	0.004	1444 a	3.0
PN	0.31 c	0.009	91.9 a	0.3	8.95 a	0.67	5.94 d	0.005	753 c	1.0
PP	0.26 d	0.010	90.9 a	0.3	8.6 ab	0.17	4.90 e	0.097	4358 d	4.0
SC	0.40 b	0.008	59.0 c	1.1	26.0 e	0.73	7.34 f	0.017	3380 e	1.0
VP	0.23 e	0.009	94.0 b	0.5	9.3 a	0.15	5.42 g	0.007	1286 f	0.6
F [1]	422 ***		1992 ***		8190 ***		2913 ***		6×10^6 ***	

[1] F values followed by *** indicate significant differences at $p = 0.001$. By columns, mean values with letters in common are statistically equal to $p = 0.05$.

For all residues, Table 2 shows a low ρ_b, between 0.23 and 0.40 g cm^{-3}. Although OP and SC get the highest values, they are far from 1.6 g cm^{-3} of soil, as ρ_b can interfere with root growth [59]. In the work performed by Golabi et al. [59], organic amendments improved soil properties and succeeded in decreasing soil ρ_b to a greater extent than inorganic fertilizers. Similar results were achieved by Yilmaz et al. [40] and Almendro-Candel et al. [60]. This means that, in general, the use of these residues can contribute positively to the reduction of the bulk density of the soil. In such a way, all residues are suitable for reducing ρ_b soils.

Table 2 shows variation in OM depending on the type of residue considered in our work. SC is the one with the lowest amount of OM, and the rest get high OM values in the range of 90–94%. OM of VP (Table 2) is like that obtained by Yilmaz et al. [40]. These residues can contribute to an increase in OM in soil [20,25,28,53,61] and is important since they may modify physical soil properties [53,59,60,62], carbon sequestration [21,63], nutrient cycling and crop yield [28,59] and bioavailability of nutrients (Fe, Mn, Cu, Zn) [64,65]. Golabi et al. [59] proved that OM could reduce nutrient leaching. Therefore, all tested residues may improve soil OM according to the amount applied, even doubling its initial content [66] and the content of recalcitrant material [67]; it is, however, subjected to environmental conditions. Rovira and Vallejo [68] considered that in Mediterranean conditions (low precipitations and high temperatures), OM decomposes faster inside soil than on soil since moisture is better retained in lower layers. So, the MC of each residue is analyzed (Table 2); CP and SC get the highest content (52.7% and 26%, respectively), and VP (9.3%) is the lowest among the studied pruning waste. Another factor is that increases in temperatures in summer affect soil microbiota, which reduces mineralization [63].

One of the key factors that determines soil agricultural potential, supply and nutrient solubility is soil pH, since it affects microbial activity, cation exchange reactions related to soil aggregation and the mobility of heavy metals [15]. Most of the residues studied (Table 2) have an acid pH (between 4.66 and 5.94), except SC which has a pH of 7.34. This result agrees with Greco et al. [15], who state that the pH range of compost is between 7 and 9 (alkaline). SC can be an interesting option for managing acid soils, given that more than 40% of arable soils in the world are acidic [36]. Nevertheless, incorporating food waste compost into the soil can increase soil pH [59,69] or decrease soil pH with PN [57]. Based on the work of Parzych et al. [56], needle pH can vary according to species from 4.00 to 5.32. The result obtained for PN pH (Table 2) is above this range (5.94). Therefore, based on Parzych's et al. conclusions [56], these data confirm the acid reaction of pine needles, which can have consequences on the mobility of heavy metals. Results agree with those obtained by Ruiz-Navarro et al. [57]; soil pH near *Pinus halepensis* showed a slight decrease related to litter decomposition.

In addition, the allelopathic potential of PN should be kept in mind, as it can affect plant growth [70]. Moreover, the allelopathic interactions between crop residues and aqueous extracts can enhance or affect nutrient availability and yield crop [71]. The most suitable soil pH to enhance nutrient absorption by plants is usually close to 6.5 [72]; PN has a pH closest to that value (Table 2). In any case, PP, OP and AP have lower pHs than PN. Most olive orchards are grown on calcareous soils, with a pH higher than 7.0 [16], so to increase microelement availability, its pruning wastes (OP) and AP residues application might reduce soil pH. PP has a pH of 4.90 (Table 2), while data on date palm compost shows a pH of 8.38 and 7.6 [52,53]. Previous work managed to reduce soil pH after applying date palm leaves compost [73]. The pH value achieved for VP (5.42) (Table 2) is like that (5.83) reported in other works [40], which led to a decrease in soil pH after the first year of application on alkaline soil. Therefore, AP, CP, OP, PN, PP and VP could be incorporated mainly in alkaline soils to control the pH. The proper choice of waste is key for crops since variations in soil pH can modify the availability of secondary macronutrients, micronutrients and trace elements that could be presented in the organic wastes and adsorbed in soil surfaces [12,16,28,72].

Among the residues considered, PP and SC (Table 2) have the highest EC. AP and PN showed the lowest EC. EC from SC is higher compared to data provided by Oueriemmi et al. [28] and like the one obtained by Jamroz et al. [43] and considerably lower than the results obtained by Pérez-Piqueres et al. [61]. This means there is high variability in SC depending on the origin of wastewater and the treatments applied to wastewater and sludge. Oueriemmi et al. [28] measured the increase in soil conductivity by application of SC, increasing soil EC according to the amount of applied SC from 750 μS cm^{-1} to more than 1577 μS cm^{-1}. Despite this increase, they consider it far from a risk of salinization ($\geq$4000 μS cm^{-1}). However, changes in soil pH, exchangeable sodium percentage and sodium adsorption ratio, among others, should be considered to assess crop vulnerability.

In this way, PP (EC: 4358 μS cm^{-1}) should be applied with caution in soils since it could increase EC, and soils can be salinized as well as SC (EC: 3380 μS cm^{-1}) although EC is less than 4000 μS cm^{-1}. On the contrary, other references consider that the application of composted organic wastes does not significantly modify the conductivity of soil [59] or can decrease it, as the application of date palm compost (3200 μS cm^{-1}) reduced soil EC after 2 years [53]. A similar EC was shown by Abd El-Gaid and Nassef [52] for date palm leaves compost. The EC of PP (4358 μS cm^{-1}, Table 2) was higher than the value obtained by the references mentioned above; it may be due to the treatment received during composting compared to the drying process chosen for this work. Furr et al. [74] did not find a relationship between the number of salts in irrigation water and the concentration of Na and Cl in the leaves of palm trees due to salinity tolerance. However, it should also be noted that EC can be increased by the contribution of organic matter applied to saline soil [53]. Considering the germination of most species and the possibilities of using some of these wastes as seed germination, this would not be affected by EC values below 1000 µS cm^{-1} [75], so residues such as AP and PN would be suitable for this purpose.

3.2. Elemental Composition and Soluble Nutrients

Hence, we are interested in addressing the contribution of soluble nutrients from organic residues prior to decomposition to determine its importance for the immediate supply of crops. The elemental composition of residues was analyzed, as well as the concentration of nutrients in aqueous extraction and their solubility index.

3.2.1. Elemental Composition

Tables 3 and 4 present the results from the analysis of macro and micronutrients (total content). The highest amount of nutrients follows the sequence SC > OP > PN > PP > VP > AP > CP. Although there are some references dealing with the organic residue's elemental composition, a previous work that compared the nutrient content of organic residues concluded that sewage sludge had the highest nutrient rate [23], which agrees with the data obtained. Navarro-Pedreño et al. [76] obtained slightly lower concentrations of nutrients, except for Mn and Zn. SC has an important mineral fraction compared with the rest of the residues, which means that it is possible to have an increased content of these nutrients analyzed.

Table 3. Elemental macronutrient composition, average content ($\bar{x}$) and standard deviation (σ) for each residue.

Residue	Na (mg kg^{-1})		K (mg kg^{-1})		Ca (mg kg^{-1})		Mg (mg kg^{-1})	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
AP	263 b	47	1698 a	191	7559 b	509	924 c	63
CP	495 c	10	1138 d	17	6649 a	93	1173 b	25
OP	160 a	33	6889 c	123	10599 c	238	1220 b	29
PN	170 a	27	1648 a	81	14059 d	220	1838 a	60
PP	1079 d	32	6858 c	470	6861 a	277	2259 d	85
SC	1529 e	44	4585 b	20	64245 e	257	5815 e	35
VP	173 a	8	4620 b	352	7609 b	244	1746 a	80
F [1]	1151 ***		419 ***		21630 ***		3314 ***	

[1] F values followed *** indicate significant differences at $p = 0.001$. By columns, mean values with letters in common are statistically equal to $p = 0.05$.

In the reverse series (highest to lowest), the elements ordered from presence in the residues are Ca > K > Fe > Mg > Na > Zn > Mn > Cu. The top 3 nutrients with maximum concentration values are Ca in SC > Fe in SC > Ca in PN, whilst the minimum concentration values are Zn in AP > Cu in AP > Cu in PP, ordered from highest to lowest (Tables 3 and 4). These results are consistent with those of Oueriemmi et al. [28] and suggest that organic residues contain a large number of nutrients that can be profitable for plants.

Asam et al. [77] analyzed pine needle (*Pinus contorta*) where nutrient content was K > Ca > Mg > Mn > Fe >Zn > Cu, and in our case, PN follows the sequence Ca > Mg > K > Fe > Na> Mn> Zn > Cu. For PN nutrient composition, compared with data from previous studies [55], K (950 mg kg^{-1}), Ca (7570 mg kg^{-1}), and Mg (1030 mg kg^{-1}) differ in part from Table 3 results. Related to micronutrients, a work carried out in Slovakia analyzed needles of various pine species other than *Pinus halepensis*, obtaining higher values for Mn, except for *Pinus nigra* and *Pinus wallichiana*, whose values are like those presented in Tables 3 and 4. Similar values of Fe and Cu were observed in *Pinus wallichiana* and

Pinus musgo. However, Zn concentrations presented in needles from Slovakia were much higher [56]. These variations may be associated with species, habitat and soil type.

Table 4. Elemental micronutrient composition, average content ($\bar{x}$) and standard deviation (σ) for each residue.

Residue	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Cu (mg kg^{-1})		Zn (mg kg^{-1})	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
AP	45 b	7	5.7 b	0.9	4.0 a	0.3	4.6 a	1.7
CP	377 a	20	38.9 c	0.5	11.2 a	1.4	5.3 a	0.7
OP	44 b	3	15.0 d	1.6	4.9 a	0.3	12.4 b	0.6
PN	371 a	26	19.4 a	1.8	7.0 a	0.8	11.4 ab	1.0
PP	88 b	4	32.2 e	2.7	3.8 a	0.4	15.7 bc	0.9
SC	18989 c	127	94.4 f	0.6	79.7 b	14.6	249.5 d	8.4
VP	44 b	2	22.2 a	1.3	8.2 a	1.3	19.4 c	1.5
F [1]	81741 ***		1480 ***		99 ***		2907 ***	

[1] F values followed by *** indicate significant differences at $p = 0.001$. By columns, mean values with letters in common are statistically equal to $p = 0.05$.

Bendaly et al. [78] studied the critical interval of nutrient concentration in palm leaves versus yield (maximum value as toxicity limit) in Tunisia palm groves. By comparing the values obtained (Tables 3 and 4), it should be noted that Mn is within the optimal yield range, and Ca and Mg are very close. Nevertheless, K is within the range estimated by Kolsi-Benzina and Zougari [79] in Tunisia, and Zn is like the one obtained by Ahmed and Al-Dousari [49] (Kuwait); Mg, Fe and Mn, also show values close to Marzouk's (Egypt) [80]. Therefore, variations in some nutrients such as Ca could result from differences in soil conditions, climate, and nutrient supplementation practices since the palm tree grove of Elche has an environmental, tourist, identity and heritage utility, while in the other, the main purpose is date production. The elemental composition of VP, except for Ca, Mg and Zn, nutrient concentration is higher in the work of Yilmaz et al. [40] than that obtained by us. Oueriemmi et al. [28] obtained similar nutrients concentration in SC for Mn and Zn, and higher for K, Mg and Cu.

3.2.2. Soluble Nutrients and Solubility Index

Tables 5 and 6 show the results from water extractable concentration for macro and micronutrients. The relevance of each organic residue according to the total amount of water extractable nutrient content is PP > OP > VP > SC > CP > PN > AP, and the elements with greater presence in the total aqueous extract are K > Ca > Mg > Na > Fe > Zn > Mn > Cu, ordered from highest to lowest. The top three soluble nutrients with maximum concentration values are K in PP > K in OP > Ca in PP, and the minimum are Cu in PN > Cu in AP > Cu in CP. What is important from those results is that the rapidly soluble nutrients may contribute to an increase in their concentrations in the soil solution and facilitate the plant absorption and accumulation in plant tissues with a single application on soil [28]. Several studies about nutrient content on organic residues have demonstrated its importance as a nutrient sink and availability for crop yield [11–14,55]. The use of these wastes to supply nutrients in a determined growth stage of a plant is one of the possibilities for adequate agricultural management, not only the use of them once during a period of cultivation.

Table 5. Water extract macronutrients average content (x̄) and standard deviation (σ) of each residue.

Residue	Na (mg kg^{-1})		K (mg kg^{-1})		Ca (mg kg^{-1})		Mg (mg kg^{-1})	
	x̄	σ	x̄	σ	x̄	σ	x̄	σ
AP	199 b	33	1163 a	31	353 c	25	208 b	19
CP	316 d	35	616 b	31	963 d	37	386 a	11
OP	88 a	7	4688 c	69	725 a	19	397 a	14
PN	121 a	4	918 d	38	686 a	16	332 c	11
PP	791 c	31	4892 e	69	4330 e	73	1662 d	41
SC	807 c	61	1468 f	62	755 ab	39	163 e	18
VP	141 ab	22	2415 g	87	810 b	15	613 f	20
F [1]	368 ***		3670 ***		5491 ***		2379 ***	

[1] F values followed by *** indicate significant differences at $p = 0.001$. By columns, mean values with letters in common are statistically equal to $p = 0.05$.

Table 6. Water extract micronutrients average content (x̄) and standard deviation (σ) of each residue.

Residue	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Cu (mg kg^{-1})		Zn (mg kg^{-1})	
	x̄	σ	x̄	σ	x̄	σ	x̄	σ
AP	1.9 a	0.1	0.8 a	0.1	0.240 b	0.020	4.2 a	0.3
CP	1.9 a	0.2	5.7 b	0.3	0.091 b	0.009	4.3 a	0.3
OP	2.2 a	0.2	3.6 c	0.2	1.144 c	0.187	5.6 b	0.6
PN	8.4 b	0.5	2.1 d	0.2	0.437 a	0.046	4.7 a	0.4
PP	1.4 a	0.2	21.2 e	1.1	0.819 d	0.105	10.5 c	0.6
SC	24.7 c	1.6	0.4 a	0.1	0.522 a	0.051	4.0 a	0.2
VP	3.4 d	0.4	5.2 b	0.3	1.116 e	0.103	6.7 d	0.5
F [1]	669 ***		965 ***		91 ***		119 ***	

[1] F values followed by *** indicate significant differences at $p = 0.001$. By columns, mean values with letters in common are statistically equal to $p = 0.05$.

Comparing the data of total nutrient content regarding soluble nutrient concentration for each residue (Figure 1), it can be observed that there is no direct relation between a higher nutrient concentration in elemental composition with the values of nutrients in aqueous extractions. SC findings are consistent with those of Jamroz et al. [43], who found a reduction in water-extractable macro and microelements due to composting process. Foereid [41] considers that although drying and composting treatments of organic waste generate a stable product, part of the nutrients can be lost, and the substrate obtained after drying can show low nutrient content. Occasionally, OM takes a long time to incorporate them by degradation into the soil profile due to the high content of recalcitrant material, as is the case for PN (lignified matter), which can be close to 60% of the total amount of organic matter and may explain PN results [67].

Extending the discussion, in most of the residues studied, the four nutrients with the highest elemental composition concentration correspond to macronutrients (Na, K, Ca and Mg), as expected, except for PN and SC, where Fe displaces Na (Tables 5 and 6). Related to aqueous extraction, the highest concentrations are obtained by macronutrients too, with K being the majority, not Ca, as in the elemental composition. The presence of all nutrients in aqueous extraction indicates they are in part soluble in water, but to know the degree of solubility with respect to the total amount of nutrient composition, a nutrient solubility index (I_N) was calculated (Table 7).

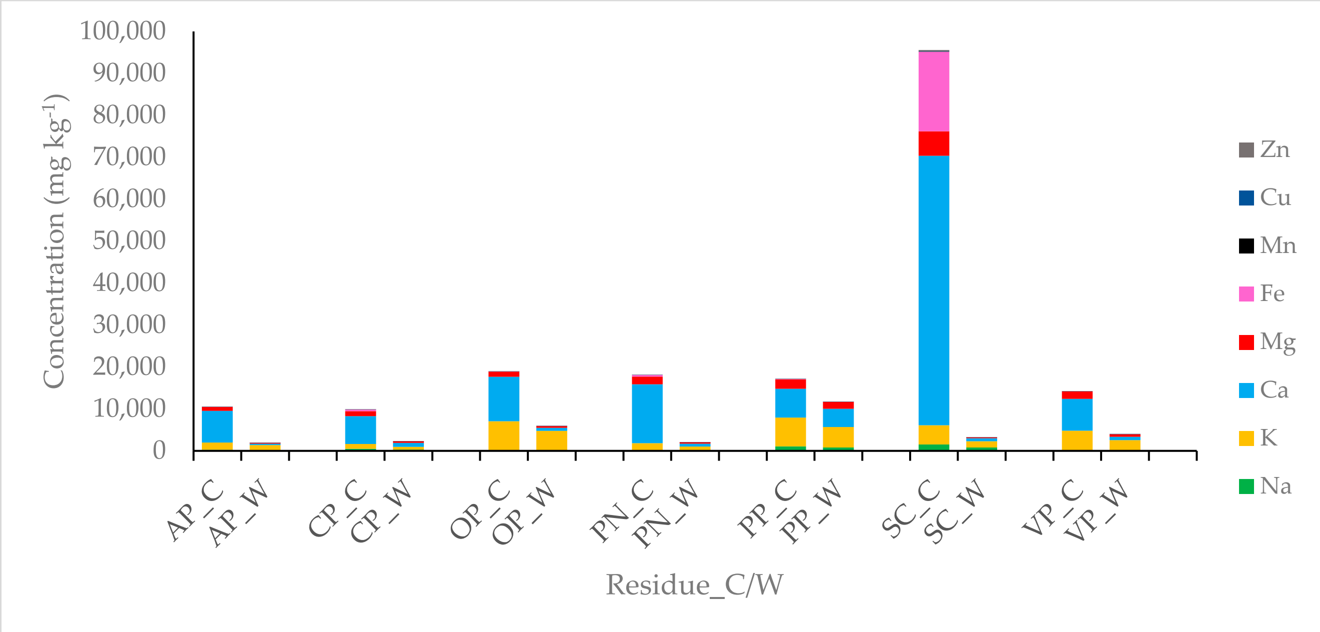

Figure 1. Total nutrient content (mg kg^{-1}) of each residue in elemental composition (C) versus aqueous extraction (W).

Table 7. Solubility index (%) of each nutrient (I_N).

Residue	I_{Na}	I_K	I_{Ca}	I_{Mg}	I_{Fe}	I_{Mn}	I_{Cu}	I_{Zn}
AP	76	68	5	23	4	14	6	90
CP	64	54	14	33	1	15	1	82
OP	55	68	7	33	5	24	23	45
PN	71	56	5	18	2	11	6	42
PP	73	71	63	74	2	66	21	67
SC	53	32	1	3	0	0	1	2
VP	82	52	11	35	8	24	14	35

Petit-Aldana et al. [42] considered chemical composition as the main aspect that determines the rate of decomposition. In the case of water-extractable forms of nutrients prior to decomposition, other factors would be of importance in determining solubility. For instance, the content of recalcitrant materials could be a factor to consider. Notwithstanding, palm leaves are composed of 66.3% cellulose + hemicellulose and 22.53% lignin [81]; PP is the first residue with the highest amount of soluble nutrients in aqueous extraction after SC but the fourth respect to the total content of nutrients (Tables 5 and 6). Therefore, the hydrophilic nature of palm leaf fibers could be a key factor [81]. In *Pinus halepensis* needles, despite their high recalcitrant content of lignin mentioned above, the decomposition on the soil leads to an increase in extractable K due to its rapid leaching capacity [11,16,57]. K, in general, is the nutrient with the second highest concentration in its elemental composition and the first in aqueous extraction (Tables 5 and 6). Zipori et al. [16] found that K (apart from N and P) is the one that is taken up in the greatest quantity from the soil solution and is the most important for olive trees due to its high presence in olives. Olive pruning residues can provide 60 kg ha^{-1} of K per year, although old olive tree leaves have less K content than younger ones. The K phytoavailable in agricultural soils is usually low, so fertilization is usually required for rapid crop development in the early stages of growth [36].

In Table 8, the order of nutrients' elemental composition does not follow the same sequence as aqueous extractions and the nutrient solubility index. Ca, Mg, Fe and Zn focus our attention. Ca is the nutrient with the highest content in the elemental composition of all the residues studied. However, in aqueous extraction, Ca becomes the second in most of them. Interestingly, based on its solubility index, Ca is among the four elements with the lowest solubility index, and this may be related to its structural function as a cell wall constituent [11]. The same trend was found for Fe, being the nutrient with the lowest solubility index in all residues, opposite to results obtained by Jamroz et al. [43]. Noteworthy is the high solubility of Mg in PP (Tables 7 and 8). The most striking result to emerge from the data is the behavior of Zn. Although Zn content lags in terms of elemental composition, it has a higher aqueous extraction, and the most interesting thing is found on the solubility index. Zn is the first of the four micronutrients, being the first in AP and CP. Previous works suggested that Zn solubility is minimum and depends on pH [29], and this may affect the importance of Zn fertilization from these organic wastes [82].

Table 8. Nutrients ordered from higher to lower concentration in elemental composition, aqueous extract and solubility index.

Residue	Elemental Composition	Soluble Nutrients	Nutrient Solubility Index (I_N)
AP	Ca > K > Mg > Na > Fe > Mn > Zn > Cu	K > Ca > Mg > Na > Zn > Fe > Mn > Cu	Zn > Na > K > Mg > Mn > Cu > Ca > Fe
CP	Ca > Mg > K > Na > Fe > Mn > Cu > Zn	Ca > K > Mg > Na > Mn > Zn > Fe > Cu	Zn > Na > K > Mg > Mn > Ca > Cu > Fe
OP	Ca > K > Mg > Na > Fe > Mn > Zn > Cu	K > Ca > Mg > Na > Zn > Mn > Fe > Cu	K > Na > Zn > Mg > Mn > Cu > Ca > Fe
PN	Ca > Mg > K > Fe > Na > Mn > Zn > Cu	K > Ca > Mg > Na > Fe > Zn > Mn > Cu	Na > K > Zn > Mg > Mn > Cu > Ca > Fe
PP	Ca > K > Mg > Na > Fe > Mn > Zn > Cu	K > Ca > Mg > Na > Mn > Zn > Fe > Cu	Mg > Na > K > Zn > Mn > Ca > Cu > Fe
SC	Ca > Fe > Mg > K > Na > Zn > Mn > Cu	K > Na > Ca > Mg > Fe > Zn > Cu > Mn	Na > K > Mg > Zn > Ca > Cu > Mn > Fe
VP	Ca > K > Mg > Na > Fe > Mn > Zn > Cu	K > Ca > Mg > Na > Zn > Mn > Fe > Cu	Na > K > Mg > Zn > Mn > Cu > Ca > Fe

3.3. Correlation between Physical and Chemical Properties and Nutrient Content

As discussed above, nutrient solubility can be driven by elemental composition and its structural function. Although Jamroz et al. [43] indicate other factors such as pH, EC and OM may play a role too. Therefore, this paper provides significant correlation coefficients between elemental composition, water extractable nutrients content and physical and chemical properties of each residue (Appendix A. Tables A1–A7). AP and VP (Tables A1 and A7) show a mostly high correlation between the elemental composition of a nutrient and the soluble concentration of that nutrient. Therefore, the presence of soluble nutrients from AP and VP residues is associated with its elemental composition. In Table A1, nutrients' elemental composition versus its soluble forms, on most occasions, shows a significant and negative (−) linear correlation (<0.7). Additionally, in Table A1 for AP, a positive (+) linear correlation is observed between the elemental composition of a nutrient and the elemental composition of another nutrient, which is significantly high (>0.7). The same correlation applies to water extractable content between nutrients (Table A1). Usually, in Table A7 for VP, correlations are similar to AP (Table A1), but the correlation between the soluble form of one nutrient and that of another nutrient is negative. The nutrients that show a significant correlation between their content of elemental composition and their own aqueous extractable content are K, Ca and Fe (−) in AP; Na (+) and Zn (−) in CP; Mg (−), Fe (−) and Mn (+) in OP; Fe and Cu (+) in PN; Mg (+), Fe (−) and Zn (+) in PP; K and Zn (+) in SC; and Ca (+) in VP.

When addressing the importance of physical and chemical properties of the wastes related to elemental composition nutrient content and aqueous extract nutrient content, differences were observed on each of the residues. OM is the most important property for elemental composition because it has more significant correlations in AP (mainly negative), OP (positive and negative) and SC (positive and negative), and for water extraction nutrients in PN (positive and negative). EC is the most correlated property for elemental composition and water-extractable nutrients in PP, SC and VP. Bulk density (ρ_b) seems to be related to water-extractable nutrients in CP, OP and SC, as well as pH is highly correlated to

PN and VP elemental composition. MC is associated with elemental composition nutrient content in OP (+, −) and AP (−)and with soluble nutrient content in CP (+). Comparing the degree of correlation between properties, we highlight OM/EC (−) for AP, PP and VP; pH/EC (−) for CP, PN and especially in VP and PP (that obtained a −1 maximum value); ρ_b/EC (−) for AP and PP.

3.4. Nutrients for Crop Nutrition and Human Health

As previously stated, K, Ca, Mg, Fe, Mn, Cu and Zn are essential nutrients for people and plants, and Na is beneficial for plants and essential for humans [29,37]. Our results indicate that it is possible to enhance the availability of all these nutrients, mainly Na, K, Ca, and Mg, in soil solution, as well as in micronutrients. Ca, Mg, Cu, Fe and Zn are one of the most lacking in the human diet [39]; therefore, if they are in optimal forms and conditions for plant uptake, this could be beneficial for human nutrition. The K needs of plants are higher than existing reserves in an assimilable form of primary elements in soil, so it is necessary to make contributions using fertilizers [17,34]. K is necessary for plant nutrition because it increases disease resistance and is involved in photosynthesis, carbohydrate metabolism and translocation of starches, seed quality and fruit formation. Humans take K for muscle and nerve activity and for proper fluid balance [5]. This element is critical for the adequate development of people.

Ca and Mg are secondary macronutrients, and the contribution of Ca from soil solution for the growth of crops is usually sufficient [16]; however, deficiency can be frequent in soils on highly weathered tropical soils [17]. This could have serious negative implications related to harvest because Ca stimulates microbial activity, reduces plant respiration, and promotes plant growth and fruit formation. Ca ingestion is vital to ensure muscle and nerve activity, immune system health, blood clotting, pressure regulation and healthy bones [5]. Mg lack in plants is observed all over the world, aids in enzyme functionality and plant use of Fe and P, mainly on strongly acidic soils [17,36] and PP could be an interesting option due to its high solubility index (Table 7) and its almost neutral pH (Table 2). Fe, Cu and Zn deficiencies usually occur in plants growing on soils on calcareous or alkaline soils (covering 25 to 30% of land surface), especially in arid and semi-arid environments, so lowering soil pH can improve its uptake [39]. Fe, Cu and Zn are involved in photosynthesis and promote plant growth. Fe acts as an O_2 carrier, Cu promotes plant reproduction and fruit flavor, and Zn takes part in seed formation. The human body needs Fe to deliver oxygen to the tissues and for brain and muscle functioning; Cu for Fe metabolism; and Cu, as a component of enzymes, DNA, RNA and proteins, promotes immune system health, as well as contributes to the perception of taste [5].

PP is the residue with the highest amount of K, Ca, Mg and Mn in aqueous extraction (Tables 5 and 6) and the one that obtains the highest solubility index for these nutrients and high solubility rates for the rest of the nutrients (Table 7). OP can provide an extra provision of Cu due to its significant concentration in soluble form and high solubility (Tables 6 and 7). SC and PN achieved the greatest amounts of Fe in the aqueous extract (Table 6). However, the Fe solubility index is 0 and 2, respectively (Table 7). Consequently, it is convenient to prioritize the use of VP, which provides the highest I_{Fe} (Table 7). Soluble Zn can be increased mainly with PP application (Table 6); although it shows a high I_{Zn}, AP obtains the highest (Table 7). The importance of an efficient nutrient supply to crops is undeniable, as well as its connections to soil, ecosystems and human health [83–85].

4. Conclusions

The use of organic wastes as amendments/substrates or forming technosols can improve crop nutrients availability and yield, ensure the presence of minerals for human nutrition, as well as ecosystem services provision. In addition, this practice would help solve the soil problems mentioned by the FAO, comply with United Nations Sustainable Development Goals and promote a circular economy in the agricultural sector.

SC, OP and PN are the three residues with the highest presence of nutrients in their elemental composition. On the other hand, if we need to apply residues to reinforce crop nutrition in a specific phase or need, residues with a greater amount of required soluble nutrients are a more advisable option. PP, OP and VP are the three residues with the most amount of soluble nutrients. Moreover, PP is the residue whose nutrients show the highest solubility indices. Incorporating crop residues into the soil is a valid option as an extra supply of rapidly soluble nutrients as well as a nutrient contribution by these by-products with a first rainwater or irrigation; however, this has been poorly studied

The presence of nutrients in elemental composition indicates that they may be available in an aqueous soil solution. However, the elemental composition does not follow the same order of the quantity of each element that could be extracted by water, as it happens for SC and PN. In fact, nutrients such as Ca show a high presence in aqueous extraction but compared to the total amount of nutrients in waste, its solubility index is low. The solubility index can be important in synchronizing the supply of nutrients with the growth phases of crops and its nutrients requirements. In such a way, organic wastes can be selected and added along the period of cultivation to supply the nutrients needed along the growth of plants, not at once. Moreover, it is convenient to continue expanding studies to determine the accurate formula for residue application, as it was developed in the past for the use of inorganic fertilizers.

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Appendix A

Supplemental and visual data related to the correlation matrix of each residue are added (Tables A1–A7). The objective of this data collection is to measure the degree of association between elemental composition nutrient content, water-extractable nutrient content and physical and chemical properties. The correlation coefficient can take a range of values from +1 to −1, so:

- −1 indicates a perfect negative linear correlation between variables
- 0 indicates that there is no linear correlation between variables
- 1 indicates a perfect positive linear correlation between variables

A positive association (highlighted in green) indicates as the value of one variable increases so does the value of the other. A value less than 0 (highlighted in red) indicates a negative association; that is, as the value of one variable increases, the value of the other decreases. The more intense the color, the greater relation. We have considered the correlation highly significant when the result is >0.7 or <0.7.

Table A1. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of AP.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	0.81250432	1																			
C_Ca	0.14327245	0.69335048	1																		
C_Mg	0.86626341	0.9950799	0.61854512	1																	
C_Fe	0.67413918	0.97831421	0.82756994	0.95297963	1																
C_Mn	0.95883748	0.94459288	0.41840093	0.97246642	0.85612062	1															
C_Cu	0.98669643	0.70692206	−0.01952985	0.77351933	0.54509325	0.89991791	1														
C_Zn	0.96137206	0.62065928	−0.13467434	0.69528889	0.44479613	0.84364022	0.9933311	1													
W_Na	0.45613064	−0.14817116	−0.81538089	−0.04946006	−0.34979792	0.18465959	0.59473872	0.6834617	1												
W_K	−0.83802062	−0.99897819	−0.66007463	−0.99854082	−0.96795354	−0.95846261	−0.7381656	−0.65546141	0.10332386	1											
W_Ca	0.13906918	−0.46429609	−0.96014142	−0.37426233	−0.63767508	−0.14785138	0.29821278	0.40627469	0.94469896	0.42379356	1										
W_Mg	−0.03572803	−0.61161216	−0.99417026	−0.53021846	−0.76221844	−0.3180315	0.12721697	0.24072851	0.87304801	0.57523102	0.98468175	1									
W_Fe	−0.90370987	−0.98385774	−0.55320505	−0.99674689	−0.92545627	−0.9880851	−0.82208223	−0.75095348	−0.03119771	0.99094014	0.29830675	0.4601598	1								
W_Mn	−0.01995167	−0.59904995	−0.99234481	−0.51677149	−0.75190751	−0.3030293	0.14285489	0.25601641	0.88063512	0.56224986	0.98731089	0.99987546	0.44609067	1							
W_Cu	−0.25990463	−0.77409514	−0.99290929	−0.70756473	−0.88843357	−0.52340339	−0.09946044	0.01592788	0.74077987	0.74469275	0.92010617	0.97430366	0.64831024	0.97062761	1						
W_Zn	−0.11693002	−0.67396233	−0.99964706	−0.59745264	−0.81236473	−0.39412441	0.04608383	0.16095073	0.8304728	0.63988533	0.96722812	0.99668377	0.53087918	0.99527542	0.98940084	1					
ρb	0.01479043	0.2929071	0.47910061	0.25351677	0.36589125	0.15094978	−0.06385303	−0.11853266	−0.42220475	−0.27529675	−0.47523975	−0.48218457	−0.21963436	−0.48216447	−0.46922399	−0.48037954	1				
pH	0.31525387	−0.18286099	−0.70020936	−0.10312115	−0.34371761	0.08847334	0.43356336	0.51044276	0.81406752	0.14671011	0.78968736	0.74140898	0.03750667	0.74671443	0.64532085	0.71111909	−0.60138839	1			
EC	0.65422693	0.37532036	−0.1716118	0.43284768	0.24305493	0.55123464	0.68918675	0.70282852	0.53705177	−0.40202111	0.35650917	0.24457326	−0.47650414	0.25501358	0.08885109	0.18977456	−0.73908124	0.816496581	1		
OM	−0.86735765	−0.52157274	0.18673139	−0.59440138	−0.35264263	−0.7424619	−0.90694741	−0.9203901	−0.67530013	0.5554322	−0.43182248	−0.28305664	0.64933293	−0.29687912	−0.07800747	−0.2106671	0.39999357	−0.104163245	−0.92462309	1	
MC	−0.7532166	−0.79575657	−0.41996847	−0.80995845	−0.74062465	−0.81168906	−0.69187389	−0.63727142	−0.06293435	0.80320783	0.20751033	0.34202251	0.81563467	0.330279	0.50022762	0.40121853	−0.62113508	-2.14284×10^{-17}	0	0.19768339	1

Table A2. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of CP.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	−0.33486222	1																			
C_Ca	0.77587396	−0.85427578	1																		
C_Mg	0.56011776	−0.96814859	0.95721653	1																	
C_Fe	−0.53299483	0.97574945	−0.94734274	−0.99947543	1																
C_Mn	−0.93701176	−0.01536149	−0.50663576	−0.23547459	0.20387558	1															
C_Cu	0.85545201	−0.77444172	0.9904485	0.90817406	−0.89414105	−0.62067403	1														
C_Zn	−0.86485446	0.76264642	−0.98773809	−0.90030238	0.88573355	0.6350239	−0.99983004	1													
W_Na	0.92278503	−0.4867443	0.83505751	0.67316297	−0.65146757	−0.79897609	0.8871992	−0.8928872	1												
W_K	0.10573156	0.16700137	−0.05374335	−0.11882145	0.12547362	−0.17351681	−0.02112534	0.01673342	−0.26916641	1											
W_Ca	0.8432277	−0.05902705	0.50457603	0.27590822	−0.2488502	−0.87261377	0.59842829	−0.61011128	0.57130169	0.60851839	1										
W_Mg	0.75848002	0.26745806	0.23926437	−0.03363327	0.06399689	−0.90379544	0.36213445	−0.37803935	0.47988638	0.53324435	0.93680076	1									
W_Fe	0.2062442	−0.1124505	0.18880959	0.15357154	−0.14881185	−0.17657886	0.1999477	−0.20114763	−0.12939443	0.96090512	0.63458165	0.46736374	1								
W_Mn	−0.15776425	0.9523447	−0.72473603	−0.87921787	0.89183612	−0.18546965	−0.62943024	0.61577607	−0.41051455	0.43361072	0.21509941	0.49555697	0.17037665	1							
W_Cu	0.80024819	0.26224752	0.26583161	−0.01794063	0.04960469	−0.94626875	0.39308797	−0.40953457	0.56267231	0.40673374	0.9081723	0.98971225	0.34173186	0.46327876	1						
W_Zn	0.90223081	−0.33365481	0.72124339	0.53311872	−0.50923171	−0.83397198	0.78929078	−0.79724721	0.98333586	−0.32924252	0.54541026	0.51782165	−0.23262265	−0.28288063	0.61405912	1					
ρb	0.9670886	−0.46391319	0.84406805	0.6648105	−0.64121623	−0.85412414	0.90421329	−0.91094682	0.8510745	0.27081242	0.87987317	0.7223271	0.40813633	−0.24232504	0.73306452	0.78872695	1				
pH	−0.50254497	−0.4377095	0.01567304	0.25123071	−0.27625923	0.69588062	−0.09703707	0.1119671	−0.5365599	0.36970376	−0.29742093	−0.53820238	0.49070839	−0.38872381	−0.64428765	−0.68031337	−0.06862071	1			
EC	0.22051955	0.39408135	−0.1419775	−0.28778787	0.30257779	−0.38059611	−0.06824985	0.05829297	0.3918819	−0.68509804	−0.10139169	0.15312712	−0.79792883	0.22723641	0.28189874	0.54328843	−0.03391492	−0.915249233	1		
OM	−0.95198524	0.34441018	−0.75585938	−0.55578307	0.53043804	0.88270606	−0.8285653	0.83708779	−0.98606136	0.20125202	−0.64916964	−0.60205769	0.10045338	0.25317028	−0.68331532	−0.99092765	0.07340175	0.55846018	−0.45241825	1	
MC	0.86159592	0.1575474	0.36988009	0.09044732	−0.05869308	−0.97279137	0.49195381	−0.50756436	0.76731459	0.01494514	0.75035081	0.85243209	−0.02313082	0.26972241	0.91790599	0.84027092	−0.04814856	−0.725764496	0.57885444	−0.9425126	1

Table A3. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of OP.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	0.98808731	1																			
C_Ca	−0.86629216	−0.7790963	1																		
C_Mg	−0.92630022	−0.97325077	0.61422771	1																	
C_Fe	−0.99805098	−0.99576509	0.83343079	0.9480077	1																
C_Mn	−0.70105462	−0.80244638	0.25109404	0.9180762	0.74418877	1															
C_Cu	0.97302673	0.92593314	−0.95816496	−0.81439319	−0.95673427	−0.51763644	1														
C_Zn	−0.07502955	0.07932478	0.56312714	−0.30622432	0.01265558	−0.65849773	−0.30304785	1													
W_Na	0.00403088	0.15787592	0.49604168	−0.380517	−0.06642616	−0.71592765	−0.22676831	0.99687077	1												
W_K	−0.77109777	−0.85989901	0.34993197	0.95417417	0.80932834	0.9946292	−0.60341308	−0.57706692	−0.63981978	1											
W_Ca	0.15850652	0.00466952	−0.63053543	0.22519827	−0.09658287	0.59297069	0.382007	−0.99646755	−0.98671099	0.5064433	1										
W_Mg	0.83381895	0.90884144	−0.44656707	−0.98036702	−0.86664302	−0.97821511	0.68397721	0.4879209	0.55539453	−0.99444778	−0.41289334	1									
W_Fe	0.78956984	0.68572507	−0.99054481	−0.50015982	−0.74973632	−0.11592551	0.90983941	−0.67117205	−0.61047305	−0.21810751	0.73105473	0.3195943	1								
W_Mn	0.00179828	−0.15211721	−0.50109469	0.3751199	0.06060876	0.71184573	0.23244174	−0.99731462	−0.99998301	0.63532907	0.98764137	−0.55053766	0.61507957	1							
W_Cu	0.00693656	−0.04361931	−0.16933155	0.11700026	0.01364518	0.22857558	0.08208795	−0.32679365	−0.32717671	0.20310461	0.32414592	−0.17497147	0.20615266	0.3272184	1						
W_Zn	0.93614848	0.97910644	−0.63533823	−0.99963446	−0.95626536	−0.90702334	0.82978497	0.28037502	0.35537553	−0.94573474	−0.19877423	0.97467762	0.52338853	−0.34992086	−0.1086939	1					
ρb	0.31053185	0.45252111	0.2039367	−0.64435493	−0.3689937	−0.8928236	0.08373515	0.92078147	0.94799209	−0.84225041	−0.88556007	0.78155704	−0.33580615	−0.94618819	−0.22723742	0.62357258	1				
pH	0.75644683	0.79477009	−0.50197018	−0.81649638	−0.77422854	−0.74937708	0.66528405	0.24948158	0.31015698	−0.77890702	−0.1833112	0.80035231	0.4088785	−0.30574899	−0.64090854	0.81621352	0.45786056	1			
EC	−0.68452074	−0.6120549	0.91724251	0.4996465	0.65531889	0.27523664	−0.79156801	0.51405308	0.41592253	0.33728808	−0.61903353	−0.39638409	−0.96565903	−0.42305762	−0.79839853	−0.51311001	−0.00254189	0	1		
OM	−0.78993611	−0.82994518	0.52418487	0.85263042	0.80849202	0.78254076	−0.69472619	−0.26052239	−0.32388297	0.81337755	0.19142364	−0.8357719	−0.42697341	0.31927991	0.59331218	−0.85233504	−0.50220696	−0.927389288	0.05961965	1	
MC	0.82382754	0.76049484	−0.88763859	−0.63200828	−0.80056828	−0.32934671	0.88198507	−0.40896114	−0.3448018	−0.41364875	0.47431791	0.49480348	0.86415635	0.3496067	−0.30308403	0.64888853	−0.05362748	0.232495277	−0.5	−0.54732691	1

Table A4. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of PN.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	0.9480079	1																			
C_Ca	0.05430222	0.36925616	1																		
C_Mg	0.1529209	0.45947393	0.99508428	1																	
C_Fe	−0.90050613	−0.71529945	0.38530223	0.29202266	1																
C_Mn	−0.24182755	−0.53805541	−0.98201936	−0.99588726	−0.20416963	1															
C_Cu	−0.82887417	−0.60774086	0.51359994	0.42610305	0.98967288	−0.342386	1														
C_Zn	−0.21781778	−0.51709848	−0.98637742	−0.99781918	−0.22825623	0.99969569	−0.3654592	1													
W_Na	−0.50560796	−0.44559903	0.07829395	0.02734762	0.50130494	0.01949711	0.47828579	0.00675841	1												
W_K	−0.71821284	−0.51116392	0.49344225	0.41713102	0.87859997	−0.34372465	0.89359084	−0.36399161	0.8023713	1											
W_Ca	0.78404163	0.56755909	−0.50873796	−0.42573935	−0.94610662	0.34614079	−0.95873593	0.36809568	−0.69772756	−0.98430124	1										
W_Mg	0.52987486	0.25652163	−0.74243398	−0.68223619	−0.81298476	0.62128898	−0.8712583	0.63838997	−0.64964877	−0.9489978	0.94122724	1									
W_Fe	0.78406957	0.59097652	−0.43533852	−0.35309396	−0.91416144	0.27481073	−0.91763093	0.29634933	−0.7854773	−0.99499546	0.9910758	0.92354887	1								
W_Mn	−0.58306353	−0.49415889	0.15211933	0.0927302	0.60503955	−0.03759845	0.58620828	−0.05264006	0.9918386	0.87064312	−0.78318684	−0.72829994	−0.85795046	1							
W_Cu	−0.73737676	−0.50942922	0.55485458	0.47600926	0.92306218	−0.39977759	0.94447239	−0.42085951	0.70847783	0.98957724	−0.9973562	−0.96237115	−0.98909479	0.79147949	1						
W_Zn	0.24537691	0.40133247	0.54272653	0.5614666	0.00963161	−0.5737771	0.09326168	−0.57089318	−0.76283828	−0.25633319	0.12983271	0.0048396	0.25935208	−0.68771079	−0.12341369	1					
ρb	−0.20856149	−0.00399872	0.59653207	0.56969743	0.45256942	−0.54024212	0.51347252	−0.5487026	−0.48548951	0.13221683	−0.28254294	−0.31254071	−0.15240883	−0.37205841	0.27281025	0.89281847	1				
pH	−0.57318028	−0.80416018	−0.84934522	−0.89744276	0.15982902	0.93371879	0.01667685	0.9246032	0.20299324	−0.02529359	0.00304207	0.32918171	−0.05720345	0.18335574	−0.06555627	−0.57506632	−0.11042356	1			
EC	0.76550903	0.9066005	0.60911259	0.67876155	−0.44220612	−0.73663717	−0.31655419	−0.72147985	−0.06864659	−0.11191428	0.20084682	−0.13900145	0.20900667	−0.10310397	−0.1298485	0.24444088	−0.04447853	−0.904534034	1		
OM	0.74579494	0.50083245	−0.60642016	−0.52620772	−0.9533076	0.4482931	−0.9806053	0.46987281	−0.57847593	−0.9504292	0.98642467	0.94988565	0.95612265	−0.67680127	−0.98528308	−0.03463194	−0.50738515	−0.035926856	0.1559078	1	
MC	0.78562801	0.58560779	−0.45678186	−0.37415702	−0.9249848	0.29534454	−0.93102568	0.31704398	−0.13839005	−0.66817192	0.78885222	0.67503371	0.71148345	−0.26197504	−0.76138186	−0.36795985	−0.78946327	−0.190940654	0.42692452	0.868022	1

Table A5. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of PP.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	−0.74024683	1																			
C_Ca	0.41568717	−0.91920513	1																		
C_Mg	0.23685616	−0.82853575	0.98208544	1																	
C_Fe	0.23608559	−0.82809142	0.98193569	0.99999969	1																
C_Mn	0.83045082	−0.98929112	0.85188714	0.73793714	0.73740169	1															
C_Cu	0.72385496	−0.07195221	−0.32661956	−0.49886988	−0.49955706	0.21675915	1														
C_Zn	−0.52576612	0.96110464	−0.99220797	−0.95095523	−0.95070961	−0.91050157	0.20631502	1													
W_Na	−0.4824873	0.50053787	−0.39452347	−0.32147093	−0.32113914	−0.51948276	−0.2021068	0.43507804	1												
W_K	−0.34593837	0.3207589	−0.2313013	−0.17540644	−0.17515792	−0.340876	−0.18402548	0.26371652	0.98031807	1											
W_Ca	−0.72722345	0.18189574	0.17986349	0.34280092	0.34346071	−0.30858813	−0.8921682	−0.06859843	0.60823029	0.60750552	1										
W_Mg	0.31593438	−0.80405712	0.9026583	0.898772	0.89868759	0.73482058	−0.35644193	−0.88750239	−0.69468237	−0.58790623	0.03436232	1									
W_Fe	−0.72241473	0.96898209	−0.88769045	−0.79856637	−0.79813082	−0.95971839	−0.07732637	0.92918708	0.69613173	0.54258113	0.29067653	−0.88102681	1								
W_Mn	0.07080543	0.25947284	−0.39247788	−0.43391971	−0.43406128	−0.1996249	0.37132075	0.35736974	0.81496396	0.84430378	0.08760703	−0.74668825	0.46656967	1							
W_Cu	−0.91453689	0.92299654	−0.71295901	−0.57211168	−0.57147559	−0.9633226	−0.40953054	0.79208589	0.66577316	0.51250727	0.54627275	−0.6726023	0.9395844	0.25725382	1						
W_Zn	−0.93230315	0.85744537	−0.61387675	−0.46258953	−0.46191779	−0.9128649	−0.50316013	0.70185209	0.27992245	0.10150355	0.43163461	−0.39394068	0.76939495	−0.18234073	0.89842599	1					
ρb	0.54166051	−0.58774494	0.47782972	0.39819724	0.39783195	0.6045902	0.20041536	−0.52109901	0.35340967	0.52634861	0.09928121	0.0692395	−0.37475252	0.61006787	−0.4602209	−0.78234989	1				
pH	−0.03630182	0.0149782	0.0009955	0.00858312	0.0086144	−0.02028996	−0.03847248	0.00404092	0.86259574	0.94340742	0.47142909	−0.42151505	0.26161139	0.87156406	0.19901775	−0.23280213	0.39984219	1			
EC	−0.76424591	0.22475293	0.01423892	0.12463364	0.1251021	−0.31817422	−0.87579774	0.05798058	−0.77680517	−0.93095704	0.70128968	0.40398583	0.0110948	−0.91493529	0.31409514	0.70889537	−0.86984547	−1	1		
OM	0.03125738	−0.04460073	0.0420228	0.03841162	0.03839352	0.04374297	0.00061142	−0.04358527	0.82680903	0.91849639	0.42976346	−0.38802356	0.20356919	0.86958434	0.13199336	−0.29928135	0.3559101	0.993340245	−0.99867922	1	
MC	−0.18675186	0.39597141	−0.42627179	−0.4166541	−0.41658207	−0.36864191	0.12929133	0.42426024	−0.59658911	−0.74272965	−0.46179102	0.00068889	0.15905095	−0.63415755	0.15508627	0.50690409	−0.55973369	−0.917742229	0.8660254	−0.92572912	1

Table A6. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of SC.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	0.30704504	1																			
C_Ca	−0.99909827	−0.26637853	1																		
C_Mg	0.35312468	0.99880551	−0.31309787	1																	
C_Fe	0.92132099	0.65290871	−0.90398937	0.68909498	1																
C_Mn	−0.6832675	−0.90468995	0.65166158	−0.92440648	−0.91339976	1															
C_Cu	−0.73105067	−0.87382799	0.70143242	−0.89651722	−0.93882123	0.99771381	1														
C_Zn	−0.95674301	−0.01688849	0.96822956	−0.06566053	−0.76835355	0.44128273	0.50091868	1													
W_Na	0.09061463	0.89289765	−0.05245881	0.88144483	0.43684568	−0.7250476	−0.68596698	0.17696902	1												
W_K	0.56986696	0.85682798	−0.53844932	0.87249983	0.8036469	−0.91307777	−0.90595024	−0.33600125	0.53916392	1											
W_Ca	−0.28581836	0.82416429	0.32621202	0.79551732	0.10922256	−0.50434565	−0.44484542	0.55220177	0.84994516	0.51884754	1										
W_Mg	−0.67491529	−0.60179199	0.65595722	−0.62766903	−0.78308923	0.764731	0.77702534	0.52392748	−0.1896566	−0.92728618	−0.19708724	1									
W_Fe	−0.42478443	−0.39107409	0.41171174	−0.40829804	−0.49796254	0.49143761	0.49846295	0.32506712	0.06363191	−0.7855212	−0.13073799	0.92694923	1								
W_Mn	0.04946238	0.8728039	−0.0106411	0.86158592	0.39599699	−0.69239293	−0.6515571	0.21567669	0.64837969	0.84713562	0.84421859	−0.66988383	−0.63943826	1							
W_Cu	0.32734066	−0.25345792	−0.34175662	−0.23029879	0.1570943	0.04668206	0.01341554	−0.41971104	−0.66183192	0.26961001	−0.46029901	−0.59695044	−0.78670171	0.05512903	1						
W_Zn	−0.56663718	0.60993211	0.60110971	0.57059193	−0.2017934	−0.2143062	−0.14781653	0.78180496	0.68891631	0.27562372	0.9509887	0.0282233	−0.00286032	0.72321863	−0.47375954	1					
ρb	0.18719894	0.38724632	−0.1711885	0.39248626	0.30731639	−0.38221493	−0.3744017	−0.07652014	−0.04204994	0.72482382	0.26756824	−0.83108069	−0.96755383	0.71738707	0.73082569	0.19848317	1				
pH	−0.37744244	−0.61757967	0.35567089	−0.62465108	−0.55260136	0.6417254	0.63468824	0.20922065	−0.82313846	−0.28640267	−0.40631361	0.00855699	−0.35223952	−0.16581116	0.73383918	−0.20449196	0.46785805	1			
EC	0.93201858	0.33082598	−0.94699286	0.3607171	0.75893615	−0.56267318	−0.59507519	−0.99994122	−0.12430061	0.77744506	−0.1319462	−0.95426281	−0.9999904	0.57492393	0.80608551	−0.46179964	0.99970394	0.240192231	1		
OM	0.59429735	0.88244469	−0.56214509	0.89875096	0.83354562	−0.9435599	−0.93670408	−0.35398569	0.59003166	0.99655156	0.53102251	−0.90462995	−0.73462205	0.83231032	0.2035939	0.27585529	0.65928545	−0.339885834	0.73473942	1	
MC	−0.23421947	0.0867505	0.24226755	0.0755625	−0.15084133	0.03694567	0.05630135	0.27443867	−0.25936502	0.37139568	0.21528476	−0.49568514	−0.77261193	0.55115468	0.69327777	0.28998782	0.8208787	0.594223121	0.8660254	0.28295569	1

Table A7. Correlation coefficients between elemental composition nutrient content, water extractable nutrient content and physical and chemical properties of VP.

	C_Na	C_K	C_Ca	C_Mg	C_Fe	C_Mn	C_Cu	C_Zn	W_Na	W_K	W_Ca	W_Mg	W_Fe	W_Mn	W_Cu	W_Zn	ρb	pH	EC	OM	MC
C_Na	1																				
C_K	0.04645054	1																			
C_Ca	0.25055823	0.97869506	1																		
C_Mg	0.01702653	0.99956668	0.97222726	1																	
C_Fe	0.68154099	0.76264727	0.87920258	0.74327736	1																
C_Mn	0.89229199	0.49241676	0.66062738	0.46658375	0.93850157	1															
C_Cu	0.18293877	0.9905607	0.99760096	0.98609657	0.84411041	0.60707307	1														
C_Zn	0.88670994	0.50301323	0.66974957	0.47735462	0.94264976	0.99992537	0.61673599	1													
W_Na	0.46813485	0.201798	0.29150972	0.18823262	0.45006248	0.49788667	0.26265663	0.49724074	1												
W_K	−0.94468598	−0.27479566	−0.46041291	−0.24722614	−0.81276334	−0.94697346	−0.4000318	−0.9442146	−0.68517802	1											
W_Ca	0.80052748	0.62413419	0.76945779	0.60112299	0.97569525	0.9797363	0.72414089	0.98165213	0.37866895	−0.86464344	1										
W_Mg	0.87688111	0.08542744	0.26286999	0.05969034	0.62987976	0.80196999	0.20430001	0.79756609	0.83260778	−0.9500773	0.67182704	1									
W_Fe	0.52799277	−0.58702595	−0.46019809	−0.60316131	−0.08754868	0.19555301	−0.50516185	0.18594681	−0.37234079	−0.22032705	0.13234219	0.15389033	1								
W_Mn	−0.03922625	−0.99539887	−0.97271972	−0.9951786	−0.75450027	−0.48391021	−0.98502011	−0.49450152	−0.28031384	0.2892172	−0.60457488	−0.12463881	0.64447062	1							
W_Cu	0.09654865	−0.43182809	−0.39895318	−0.43503512	−0.25474995	−0.11228043	−0.41194618	−0.11755745	0.74016876	−0.19832527	−0.28480729	0.49318191	−0.20802152	0.34519384	1						
W_Zn	0.14064613	0.6559263	0.66435351	0.65243045	0.57081214	0.41795107	0.66469058	0.42423811	0.82899324	−0.45687904	0.40653445	0.50981472	−0.76323795	−0.72349156	0.39747465	1					
ρb	−0.40059598	−0.53123708	−0.59743438	−0.51989387	−0.64934195	−0.59018162	−0.57797318	−0.59351513	0.37661002	0.3204634	−0.71172183	−0.01093732	−0.34409558	0.45361579	0.86435026	0.17684453	1				
pH	0.36063774	0.7480855	0.79932016	0.73813111	0.7821383	0.65311811	0.78586972	0.65905576	−0.19911319	−0.37548149	0.78701774	0.0724138	0.08231886	−0.68713212	−0.80179173	0.09516276	0.13766461	1			
EC	−0.94331242	−0.71726779	−0.80008769	−0.70376316	−0.93858352	−0.99341334	−0.77446066	−0.99231278	−0.10043913	0.98735117	−0.99072804	−0.91832098	−0.18951902	0.65676725	0.87909068	−0.21622293	0.95375317	−1	1		
OM	−0.4430745	0.5856372	0.47671495	0.59921036	0.14280418	−0.12045939	0.51572057	−0.11139733	−0.66884519	0.43179886	0.07969336	−0.67718286	−0.21711018	−0.52319183	−0.89799277	−0.16050968	−0.24152539	0.609046041	−0.99460059	1	
MC	0.32415499	−0.41058326	−0.33156513	−0.42047974	−0.09175732	0.09570325	−0.35979366	0.08927135	0.80559654	−0.40423369	−0.09045727	0.66942632	−0.06509893	0.33039427	0.97280245	0.39927339	0.66191753	−0.233126202	0.8660254	−0.83912893	1

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