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Non-Fungible Plant Variety (NFPV): A Proposal for an Innovative Way of Controlling Seed Trade of Protected Plant Varieties

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Abstract:- This work proposes the developing of a blockchain smart contract and the formal creation of Non-Fungible Plant Variety (NFPV) by tokenizing such a real-world asset. The NFPV enables complete transparency of the seed market by establishing an unprecedented relationship between the breeder of the plant variety and the acquirer of the seed of such plant variety.

Each digital token of an NFPV is backed by a seed unit of the same real-world variety produced that year by the breeder. A digital token of an NFPV cannot exist without the backing of a seed unit of the same variety, nor vice versa. Purchasers of the NFPV will have the opportunity to bid in the ICO (initial coin offering) for the purpose of determining the valuation price of the NFPV and its copy in case of seed save and use, the base price of which will be the real-world production value of the seed containing the variety. The transaction will be made through the standard for non-fungible tokens (NFT) in the Ethereum ERC-721 network using the Solidity language, the transaction being credited with the network's cryptocurrency Ether (ETH) and the MetaMask virtual wallet or digital purse.

The work described here is the creation and commercialization of the seed of an NFPV, a concept that is perfectly in line with the obligations of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) and the system of intellectual protection of the Union internationale pour la Protection des Obtentions Végétales (UPOV).

NFPVs may be particularly relevant in the case of specialty crops.

Keywords:- *Plant Varieties, Plant Breeders´ Rights, Intellectual Property, Sui Generis System, Non Fungible Token, NFT.*

I. INTRODUCTION

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) is the most relevant and comprehensive multilateral agreement on intellectual property (IP) of the history. The TRIPs Agreement is Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization (WTO), signed in Marrakesh, Morocco on 15 April 1994, and it has been ratified by 164 members. According with Section 5: patents, Article 27, Patentable Subject Matter, paragraph 3b, Members may exclude from patentability … plants. "However, Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof" [1].

To protect plant varieties, most countries ratified the sui generis system of the Union internationale pour la Protection des Obtentions Végétales (UPOV) which contain a comprehensive set of rules for their members regarding Intellectual Property Rights (IPRs) over plant varieties. The UPOV system, however, is not mandatory and WTO members have complete freedom to develop some form of intellectual property protection for plant varieties. This means that there is flexibility to design a sui generis system appropriate for the characteristics of the agricultural system of each country and, obviously, for the controlling the seed trade of the protected varieties [2]. Some countries like India or Malaysia have opted to depart significantly from the one-size fits all model of UPOV 1991 and adopt national Plant Variety legislation that includes unique features, with a high integration of key issues from genetic resources international treaties [3]. In any case, however, the technical progress and the increasing complexity and speed of plant innovation (the development of new breeding techniques in particular) together with the dematerialization of plant genetic resources, are indicators of the weaknesses of the current plant intellectual property rights systems [4]. So, radical redesign of such systems for the protection of plant innovations has been already advocated. Rapela suggest a "Plant Germplasm Integrated System" as a comprehensive and inclusive proposal for the protection to all kind of plant innovation, including plant varieties, heterogeneous plant varieties, microorganisms, biotechnological developments, genetic resources, and biosafety [5]. Metzger and Zech suggest a unified protection regime which should replace the current plant breeders´ rights and patent system [6]. Kock suggest a "holistic system" which combines element of patents, plant breeders´ rights, biotech regulatory and the International Treaty for Plant Genetic Resources [7].

One of the conflictive issues of the UPOV treaties is the so called “farmer’s exception” which allows member countries to restrict the breeder’s right, permitting farmers to save and use propagating material obtained from their own holdings, to subsequently grow crops. Under the 1978 Act of the UPOV Convention no specific mention is made on this regard. Under the 1991 Act of the UPOV Convention, however, there is an optional exception to the breeder’s rights according to which UPOV members can decide to allow farmers to replant seed on their own farms without the authorization of the breeder [8]. It is a matter for each UPOV member to decide if, and how, to incorporate this exception in its legislation that leads to extremely erratic results which, in many cases, do not safeguard the legitimate interests of the breeder. Extensive worldwide studies carried out by experts from the International Seed Federation on wheat [9] and soybean seed [10] reveals that countries developed different systems for the control of the farmer´s exception and the subsequent collection of royalties. Consequently, legal, political and practical factors in agriculture influence the effectiveness of the royalty collection process, which can be completely ineffective to the point where, in some countries, the most important seed market is the illegal market.

We present in this article an original, sui generis and innovative way of controlling the seed trade through the creation of the Non-Fungible Plant Variety (NFPV), as an integral, intangible, and non-exchangeable token of a Plant Variety that is also intangible, unique, distinguishable, homogeneous, and stable, as product of the expression of the characters resulting from a certain genotype or from a certain combination of genotypes contained in a tangible seed.

II. THE "PLANT VARIETY" OF THE REAL-WORLD: REGULATORY FRAMEWORK

According to UPOV, "the term <species> is a familiar unit of botanical classification within the plant kingdom. However, within a species there can be a wide range of different types of plant. Farmers and growers need plants with particular characteristics and that are adapted to their environment and their cultivation practices. A plant variety represents a more precisely defined group of plants, selected from within a species, with a common set of characteristics” [11].

The definition of "plant variety", however, is not found in the UPOV Convention of 1978, but in the Convention of 1991, which has been widely adopted in different countries. Article 1. (vi) of the 1991 Act of the UPOV Convention defines that "variety means a plant grouping within a single botanical taxon of the lowest known rank, which grouping, irrespective of whether the conditions for the grant of a breeder's right are fully met, can be defined by the expression of the characteristics resulting from a given genotype or combination of genotypes, can be distinguished from any other plant grouping by the expression of at least one of the said characteristics and considered as a unit with regard to its suitability for being propagated unchanged” [12]. It follows that the three subjective elements that characterize a plant variety are distinctness, uniformity, and stability.

The "explanatory notes" prepared by UPOV on the definition of "variety" indicate that it is "a plant grouping within a single botanical taxon of the lowest known rank [...]", thus confirming that a variety cannot be composed of plants of different species, and that by defining a variety as a "plant grouping", it makes it clear that a single plant, a part or parts of a plant, a trait, a chemical substance or DNA, does not constitute a plant variety. The authorities of each national office examine whether the application satisfies the requirements for the grant of a Plant Breeder's Right, in particular, whether the candidate variety is distinct, uniform and stable (DUS). A variety that meets the DUS criteria conforms to the definition of a variety [13].

Everyday jargon, including that of some specialized media, tends to use the terms "seed" and "plant variety" as synonyms, when they are clearly dissimilar and correspond to different regulatory figures. "Seed", means that part of the crop species which is used for propagation either as a seed in botanical sense which is developed from a fertilized ovule, or a seedling, or some other parts such as a corm, cutting, bulb, root scion, set, split, tuber or stem, which is not a seed in a botanical sense, and which is used for vegetative propagation” [14]. Clearly, the terms "seed" and "plant variety" refer to different objects. “Seed" is a tangible object whose regulation concerns aspects of its trade, while "plant variety" is the expression of the characteristics resulting from a given genotype or combination of genotypes and is therefore intangible. Farmers acquire seeds, which only when sown and after their development, express the genetic information contained in the form of a plant variety.

Due to the mandatory requirements of the property title, no two identical plant varieties of the same species can exist, nor can they have been pre-existing in nature. A plant variety is unique by nature and legal definition, and belongs to the breeder, the person who accredited and requested before the respective authority the issuance of his Breeder's Right on such variety. If there are two identical plant varieties of the same species, at least one of them would be subject to the application of the nullity clauses of the issued property title.

III. THE BLOCKCHAIN TECHNOLOGY

To comprehend the Blockchain technology it is necessary to understand some of the reasons for its birth. Perhaps some linked to the technological dynamics, but also to the idea of trust. Trust that is based on the verification of many people. That collective certainty requires a verification that allows to generate a point of progress that is immutable, not manipulable and that allows to build on a common base.

In an age of counterfeits in many social, cultural, economic and political aspects. Blockchain technology attempts to build on trust by abandoning the centrality of the source and generating a decentralized information system that guarantees transparent transactions.

As the World Intellectual Property Organization (WIPO) [15] points out, the birth of blockchain involves the discovery of a new system that allows untrusted participants to maintain a consensus on the existence, status, timing and evolution of a series of shared events. In other words, blockchain can create an immutable record of transactions, linked to participants, rather than non-participants, that does not give rise to opportunities for fraud, given the characteristics of the technology on which the record is based. The potential distrust between participants is resolved by the existence of a global computer network, characterized by nodes that consensually validate all transactions that take place in this network and thus manage the distributed database.

In an aseptic definition we could say that the Blockchain is a shared and immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible (a house, a car, cash, land) or intangible (intellectual property, patents, copyrights, trademarks). Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and costs for everyone involved.

Now, properly speaking, we can highlight that this protocol acts as a chain of blocks of information linked together in a decentralized and public way, stored in interconnected computers through a network of distributed computers, the nodes. The nodes work collaboratively to store, share and preserve the distributed record, using a consensus algorithm to check and guarantee the validity of each block [16].

In a technology called "distributed ledger technology" (DLT) that allows the creation of networks to record economic transactions and this based on certain principles such as: a) all validating nodes (computers) in the network have a complete and updated copy of the transaction ledger; b) the transactions carried out in a given period of time are grouped into information packages ("blocks") and the consistency of the transactions with the copy of the ledger must be verified; c) the incorporation of each block issued by each validating node must be verified and validated by consensus of the nodes; d) once a block is approved, it is included in the logbook and is irreversibly linked to the previous block, forming a "chain" that will be unalterable[17].

This implies that the blockchain has the characteristics of decentralization, irrevocability and immutability.

A blockchain database is structurally organized into blocks of transactions that are mathematically linked together in a chained fashion, so that modifying a block would be impossible as it would generate a discrepancy in the system with respect to the rest of the blocks that would invalidate the transaction.

Participants in a blockchain do not log in with a username and password, as in traditional systems. Here, participants are authenticated with the use of private key signature pairs (cryptographically related) that are automatically generated. These private signature keys allow access to modify the "signer-owned" assets in the ledger database, allowing the network consensus to check the validity of a transaction made within the network.

The decentralized networks of nodes in which the various blockchains are structured can be technically divided into two types, permissionless net or permissioned. The former do not require any type of permission to be able to participate as a validating node (miner) [18].

However, we mentioned that this technology seeks to avoid fraud. To this end, a proof-of-work system is applied whereby the node, before incorporating a new block, must solve a set of mathematical algorithmic problems.

Permissioned networks, on the other hand, are based on a different trust system. Here we find hierarchies of validators. Consequently, a limited number of nodes can access the network as validator nodes, depending on the requirements established (for example, having a minimum number of tokens). Thus, the incorporation of a new block will depend on it passing either a proof of authority or a proof-of-stake.

Thus, the rule for making decisions is one of those that can be found in the following chart:

Consensus Model	Explanation
Proof of work (PoW)	The PoW model requires users who want to publish a new block be the first one to solve a computational puzzle to demonstrate that work has been done to gain the solution to the computational puzzle. The user who first resolves the puzzle will have their solution verified by other nodes on the network. The puzzles are designed in a way that is hard to solve and easier to verify. When other nodes verify the solution to the puzzle submitted, the solution is either accepted or rejected in accordance with established consensus requirements.
Proof of stake (PoS)	In the design of a PoS model, stake is held by a facility/arrangement established by consensus. The ability of a user to succeed in publishing a new block on the chain is proportional to their stake invested in the chain.
Proof by authority	For proof by authority to be implemented, nodes on a blockchain network must have their identity at least visible to the “owner” or the managing authority of the chain. The node seeking to publish a new block is staking its reputation and/or authority to publish.

Table 1: Consensus Model

Enunciated the main consensus models, it is necessary to determine who can participate is determined by the degree of access to the network. This will define the degree

of transparency, the more they verify, the more reliable the transaction.

As mentioned above, there are open-access or public networks and others with restricted access. This generates debates about the evolution of decentralization and the transparency of the decision. However, this is not a problem that we will investigate in this article, but how to represent an intangible asset and how to represent virtually and cryptographically goods or rights existing in the real-world.

When applied in the real-world blockchain allows users to maintain and control the use of their own assets and data. This is made possible by the immutability that blockchain provides. In addition, by using smart contracts to facilitate commerce through blockchain, users can subscribe to transactions through smart contracts and receive tokens (i.e., coins) that represent a given value or the right to use a service/asset as agreed upon through the smart contract.

IV. THE SMART CONTRACTS

Smart contracts can be defined as autonomous programs that mechanically execute the requirements previously registered in a blockchain according to the instructions given by the contractors and that by the very nature of the blockchain will have a series of characteristics such as authentication, inalterability, transparency and traceability [19].

Smart contracts are necessary to trigger automatic transactions between blockchain addresses. In general, it is possible to use smart contracts as a means to execute legally binding transactions. The crucial factor is the intention of the parties [20].

However, it is up to the legal systems to recognize smart contracts as contracts. Here the offline world still has a preponderance over the online world.

Therefore, smart contracts are computer programs that run on the blockchain and can be used for any conditions that can be programmed. If certain conditions are met, such as the occurrence of an event or the violation of a contractual obligation, the software automatically triggers the intended consequence. It is true that smart contracts can be programmed on any computer or platform outside of a blockchain.

However, in a Web3 context a smart contract becomes important when deployed on a blockchain. This is because in combination with a blockchain, there is no need to rely on a central server and the distribution is safeguarded by the data structure of the chain as well as its encrypted transactions. Without using a blockchain, smart contracts face the same obstacles as centralized databases; specifically, if the database fails, the smart contract will fail as well, and since any changes to the smart contract are difficult to track, they can be easily changed or manipulated [21].

Smart contracts on blockchain are already used for various intellectual property use cases, such as music distribution. People who listen to the music automatically pay for it through their (blockchain) account. The idea is that no middlemen are needed, and artists receive their royalties directly. In general, smart contracts are programmed with "if - then - if not" conditions [22].

The smart contract is self-reinforcing, since it is constructed based on objective transaction data and not on interpretations. That is, the condition is either fulfilled or not fulfilled. Here there are no terms subject to further interpretation.

Thus, the program verifies whether the conditions are given to proceed with the transaction and that generates the payment. The smart contract is programmed, for example, with the arguments "verification of the intangible asset", "verification of the requested use", "verification of the amount of the rights", "verification of the signature of the corresponding account" [23]. If one of the requested data does not match the terms of the smart contract, an error is returned, and the transaction is not completed. In the case we are considering in this article, the contract will verify if the user is authorized, if his authentication is valid, if he is authorized to use the non-fungible asset and, if applicable, it can also determine with associated geolocation technology if it is going to be used in the authorized territory.

Consequently, licenses and intellectual property transactions can be carried forward on the blockchain and with it, the traceability of copyrights, trademarks, designs or patents can be ensured. This means that all intangible assets can be programmed with a smart contract. One might ask whether these individual blockchain applications and smart contracts could be protected by copyright, just like software. It is not the task of this article to unravel that doubt. However, it is a question to be probed to see the different forms of protection [24].

In this sense, it should be noted that the application of smart contracts has more than one function in intellectual property. Firstly, they can be applied to the registration of intangible assets. In particular for trademarks, patents, industrial designs and utility models. In other words, those industrial rights that require registration to attribute ownership of an innovation or its name [25].

Secondly, for the management of rights. This involves securing commercial transactions and here the case we are dealing with or the licensing of intangible assets protected with intellectual property acquire a notable relevance. The example of the music industry in this respect is relevant, as it is for the audiovisual industry. In this way, it is possible to take the example of economic sectors based on human creativity and apply it to more complex cases such as the one we are analyzing.

Thirdly, we find ourselves with the function of traceability to reduce the incidence of piracy and counterfeiting. As Collen points out: “Blockchain facilitates supply chain coordination between manufacturers, shippers, middlemen, and delivery, ensuring only legitimate goods enter the supply chain and are delivered to consumers. Customs authori-

ties can reference supply chain blockchain to validate legitimate goods or identify counterfeit goods" [26].

For the purposes of this article, we will focus on the possibilities of how a plant variety management strategy can be developed. However, Guadamuz [27] warns of the problems that exist in relation to the complexity of adapting smart contract technology given the variation in management possibilities. It is important to start from the basis of whether it is not possible to complement the various advances in terms of tokenization of real assets and, where appropriate, propose a management model that achieves the same as they have achieved in other scenarios with equally complex relationships.

Thus, we take as an example the start of non-fungible tokens and the metaverse. In particular, we refer to the case of Decentraland. You may wonder what relation this has with the idea of metaverse or with the uses it allows. Precisely, one of the problems of the beginnings of Decentraland was to prove the ownership of a plot of land in this parallel reality and so they expressed it in their white paper: "With the launch of the Iron Age, we are introducing two digital assets: LAND, the *non-fungible parcels* in which the virtual world is divided; and MANA, an ERC-20 token that is burned to claim LAND, as well as to make in-world purchases of goods and services. The utility of LAND is based on its adjacency to other attention hubs, its ability to host applications, and also as an identity mechanism. Developers and other content creators will demand LAND so that they can build on top of it and reach their target audience. Although every unclaimed LAND can be purchased at the same exchange rate (1000 MANA = 1 LAND), LAND parcels are distinguishable from each other, potentially trading at different prices on a secondary market due to differences in adjacencies and traffic. On the other hand, MANA serves as a proxy to assess the price of a new parcel of LAND. Also, MANA used to buy goods and services in the virtual world creates utility value for the token" [28]. Before moving forward, it is necessary to clarify a concept.

When we talk about Metaverse we say that it is a post-reality universe, a perpetual and persistent multi-user environment that merges physical reality with digital virtuality. It is based on the convergence of technologies, such as virtual reality (VR) and augmented reality (AR), which enable multisensory interactions with virtual environments, digital objects and people. Thus, metaverse is an interconnected network of immersive and social environments on persistent multi-user platforms [29].

It is an environment where humans interact and exchange virtual experiences using avatars, through a software in a cyberspace, which acts as a metaphor for the real-world, but without necessarily having its limitations [30]. It is generally composed of multiple three-dimensional virtual spaces, shared and persistent, linked to a perceived virtual universe.

In this case, taking the example of Decentraland, we can ask ourselves if it is possible to create or develop a relationship scheme that allows us to replicate the metaverse property management model, but to do it for the management of an intangible asset. Let's see graphically how the Decentraland model works:

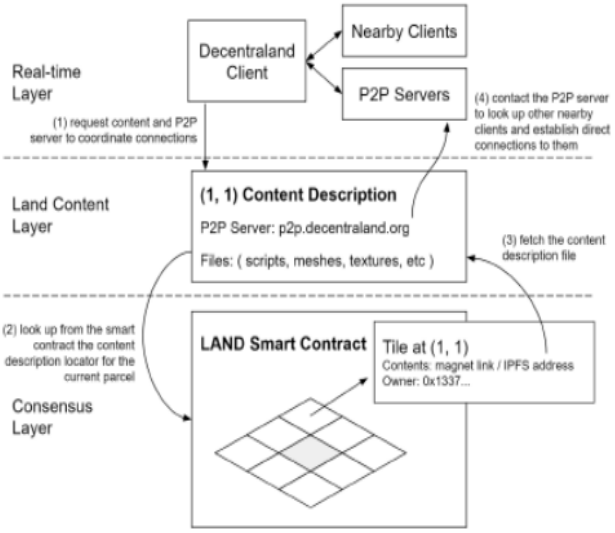

Fig. 1: The Decentraland protocol for simultaneous users in a decentralized virtual world [31].

Following the example of Decentraland, we can draw a parallel with the management of intellectual property. In this case, we can create an ecosystem that contemplates the possibility that all actors in the value and distribution chain can participate and use intellectual property, subject to payment of the corresponding licenses and authorizations.

To this end, the innovation and value capture model must contain the element shown in Figure 2:

Fig. 2: creation of the authors

The blockchain innovation management model will be determined by the characteristics of the network. However, according to Buterin and Poon [32], it is possible to create incentive schemes for smart contracts to operate large amounts of transactions and with them, generate scalable management models in real time.

The proposal of these authors is called "Plasma" and is a strategy that, starting from a private network, allows transactions to be scaled according to scheme of Figure 3:

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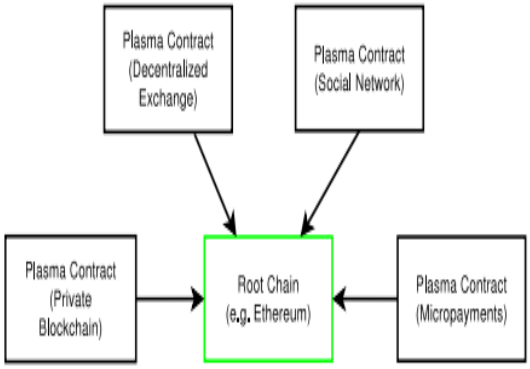

Fig. 3: creation of Poon and Buterin [33].

Poon and Buterin explains that “anyone can create a custom Plasma chain for smart contract scalability for many different use cases. Plasma is a series of smart contracts which allows for many blockchains within a root blockchain. The root blockchain enforces the state in the Plasma chain. The root chain is the enforcer of all computation globally, but is only computed and penalized if there is proof of fraud. Many Plasma blockchains can co-exist with their own business logic and smart contract terms” [34].

In the vision of these authors the problems presented by the multiple relationships that can generate complex situations. In addition, it allows for improved security and backup of that which is recorded on the blockchain. This is made possible by Etherum's new adoption of the PoS consensus method.

This means that all the problems have been solved. On the contrary, it means that there is a possibility and that this possibility makes it possible to manage transactions of multiple actors in a network and verify them with higher security capabilities. In addition, it creates an environment that makes it possible to evolve the application of smart contracts, which shows a more than interesting management path for intangible assets.

V. THE THEORY OF DECENTRALIZED INTELLECTUAL PROPERTY (DE-IP)

Previously in this article we mentioned that decentralization was one of the features of Blockchain technology. That, according to the different consensus methods, it could be achieved that the verifier nodes could immutably imprint a piece of data on the blockchain.

However, this brings as a consequence that many activities that could be carried out through intermediaries can be replaced by these consensus and immutability mechanisms.

With this technology, decentralization implies a new intermediation scheme. That scheme requires understanding whether it is possible to apply this to intellectual property. To do so, we will first look at the example of finance, an industry where it has been applied with exponential dynamics and is obtaining interesting results.

Decentralized finance (DeFi) is an emerging financial technology based on secure distributed ledgers similar to those used by cryptocurrencies.

Decentralized finance uses the blockchain technology used by cryptocurrencies. A blockchain is a secure distributed ledger or database. Applications are used to manage transactions and run the blockchain.

On the blockchain, transactions are recorded in blocks and then verified by other users. If these verifiers agree with a transaction, the block is closed and encrypted; another block is created containing information about the previous block.

The blocks are "chained" through the information in each previous block, which gives it the name blockchain. The information in the previous blocks cannot be modified without affecting subsequent blocks, so there is no way to alter a blockchain. This concept, along with other security protocols, provides the secure nature of a blockchain.

This is also the case in the financial sector. In the field of intellectual property, some authors [35] postulate the idea of decentralizing intellectual property by taking advantage of the characteristics of automation, decentralization and transparency offered by smart contracts and in particular, with the emergence of smart contracts.

Consequently, it seems that an ecosystem could be created to help achieve this operational decentralization while guaranteeing the exercise of intellectual property and its exclusive rights.

IP functions as a business tool for value creation, a vehicle for investment and a relationship between rights holders, users and society. If we focus on the narrow view of IP as a "mere legal title that confers the right to exclude others," we will miss the complexity of how IP functions in our knowledge economy. Adopting a holistic view of IP as a complex adaptive system will help us better understand IP in actual practice [36].

For this it is necessary to understand how uniqueness can be safeguarded with non-fungible tokens and how this value can be protected, being a reflection of an exaltation of the right to property.

VI. TOKENIZATION AND UNIQUENESS

Before specifying how we can represent a plant variety as a token. It is necessary to understand what tokenization is. That is, what does it imply and what does it mean. Tokenization is the technical process of producing a token. In short, tokenization is nothing more than creating a legal fiction that allows the development of a kind of virtual "parallel world" identical to the real one [37].

So, by tokenization we mean the process of converting physical, financial, or intellectual assets into a digital token. Typically, an asset is divided into smaller parts that are converted into many tokens on the blockchain.

Once the asset has been tokenized, the owner can trade it in the digital world, which could affect the asset in whole or in part.

Intellectual property can be represented by a cryptographic token. Tokens on a blockchain are managed by smart contracts and represent programmable assets or access rights. Only those who have the private key to access the token can use and dispose of it.

As cryptographic tokens enable a unique digital representation, they make it possible to represent and transfer any ownership or right to an asset.

In addition, rights holders can authorize other parties to create and have them create and manage tokens on their behalf, or to record events and information about their rights or assets.

There are basically two ways to create a token on a blockchain: mining and minting. As described above, nodes in a blockchain network are rewarded in cryptocurrency, i.e. with tokens representing the respective cryptocurrency, for mining the next block [38].

Token minting, on the other hand, is done by means of smart contracts. A smart contract function is called that can create an unlimited number of tokens.

Now, there are several kinds of tokens, but we are interested in differentiating between those that are fungible and those that are not. The non-fungible tokens are the basis of our proposal. To understand their use, it is necessary to understand that intellectual property ensures exclusivity for a certain period of time to the holder of the rights over intangible assets, in order to allow value capture and the consequent reward for innovation.

In this sense, since the emergence of the concept of a non-fungible token, many definitions have been attempted. Some authors consider that: “Non-Fungible Tokens (NFT's) depict a digital certificate of authentication being created on the blockchain technology which is similar to other virtual crypto assets and currencies” [39]. For them it is the representation, by means of a certificate of something unique and singular. However, there are other authors who go a little further and in a technical explanation mention: "NFTs are being utilized to store shrewd agreements and verification for advanced art and other computerized resources. A record is made on the blockchain that records an exchange related to meta-information. Meta-information is generally going to be a URL that connects to an advanced resource, say a computerized picture or an advanced video. Thus, when an NFT gets put onto the blockchain, it records the terms and verification of the exchange identified with that computerized picture. It resembles an advanced mark” [40].

In short, we can say that NFTs are non-fungible tokens, these are digital representations of value (e.g., a right or an asset) that are not consumed with use, that are "unique" and that are created using blockchain technology [41].

We propose to build on this representation of value through non-fungible tokens to manage the intellectual property of a plant variety and its commercial derivations. This is through a model of licensing and authorization of use, through a system of authentication and payment. This network will in principle be hybrid, to allow the incorporation of new users, with a PoS consensus mechanism and with automatic elements that allow the development of a management network for these intangible assets.

In the following section we develop the operation of the network.

VII. THE NON-FUNGIBLE PLANT VARIETY

While fungibility refers to the property of an asset whose individual units are interchangeable and essentially indistinguishable from each other (examples are money or digital currencies), a Non-Fungible Token (NFT) is a type of cryptographic token that represents a unique asset. NFTs can be tokenized versions of digital or real-world assets [42].

Due that NFT is a unique token, it belongs to the person who bought it, acquired it or made it. Although the NFT is a digital token, and so it can be copied, the ownership of that token is marked in a ledger (usually the Ethereum blockchain). In other words, the owner of the NFT has a record that they own that token [43].

Real-world asset tokenization is the process of creating digital tokens fully backed by a physical asset and is beginning to establish itself as a new mechanism for digital trading of such assets. This tokenization opens more business opportunities as the tokens can be traded 24/7, and the asset can be split into parts. Tokenization of real-world assets is made possible by the existence of legally binding smart contracts, which generate agreements between owners and sellers within the blockchain. There is already a history of tokenized assets in art, real estate, equities or organic wine commodities [44].

A Plant Variety is by definition a unique asset and if it holds a property title through Plant Breeder's Right, it is subject to the following authorizations by the holder: (i) production or reproduction (multiplication), (ii) conditioning for the purpose of propagation, (iii) offering for sale, (iv) selling or other marketing, (v) exporting, (vi) importing, (vii) stocking for any of the purposes mentioned in (i) to (vi), above [45].

What is specifically proposed in this work is to develop a blockchain smart contract to help ensure transparency and formal creation of Non-Fungible Plant Variety (NFPV) by tokenizing the seed of the real-world asset, with the following features:

- No seed of a tokenized non-fungible variety or NFPV may be offered for sale on the physical plant variety market.
- Only the real-world Plant Variety holder can create the NFPF of the seed corresponding to that variety and offer it for sale through a blockchain smart contract.

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- The "seed unit" is the tangible marketing unit in the real world, that is, it is the bag, packaging or can containing the seed inside of which is the genotype or combination of genotypes expressed in the Plant Variety.
- The asset is fractionable into parts in such a way that the number of tokens issued is in accordance with the number of seed units of the same variety available in the real world.
- Each token is backed by a unit of seed produced that year by the breeder. Therefore, a digital token of an NFPV cannot exist without the backing of a seed unit of the same variety, nor vice versa.
- After each planting and harvesting cycle, the acquirer of the real-world seed can reserve and use seed of the tokenized variety as many times as he wishes, as long as the new seed units are backed by new NFPV of the original variety provided by the breeder.
- Any planting of real-world seed units that are not backed by the corresponding NFPVs constitutes a violation of the smart contract.
- To generate complete transparency and an unprecedent type of relationship between the seller and the buyer, each buyer is the one who defines the price of the NFPV and its copy. In other words, the price of each token or NFPV is defined by the buyer, not by the breeder of the variety. Also, in this operation, the price of the NFPV copy certificate must be included in case the real-world seed acquirer reserves and uses seed after each planting and harvesting cycle.
- For this dynamic, the buyer will know in advance the number of tokens or NFPV to be offered for sale.
- With the above data, buyers of the NFPV will have the opportunity to bid in the ICO (initial coin offering) to determine the valuation price of the NFPV and its copy, whose base price will be the production value of the seed containing the variety in the real world.
- The transaction will be made through the standard for non-fungible tokens (NFT) in the Ethereum ERC-721 network through Solidity language, paying the operation with the cryptocurrency Ether (ETH) of the network and the virtual wallet or digital purse MetaMask.
- The choice of the Ethereum network is because to date the network provides all the smart-contract facilities, both for the issuance of tokens, as well as for the registration and tracking of the availability of production. Other standards can be chosen to the extent that the ERC721 standard of the Ethereum network ceases to be the market's default platform.
- The ERC-721 standard provides a token model for collecting supply chain data, supplier payments, traceability of products and offers, execution of contracts and, at the same time, a mechanism for further developments, such as procurement automation, order inventory and other processes.
- Smart contract details are on the blockchain and visible to all participants and comply with global and country-specific regulations for shipments, which also speeds up orders and deliveries.
- By the time the physical seed units are ready, they will have printed the QR code that identifies them with the NFPV purchased.
- The breeder of the real-world variety has the right that, if the number of bids for purchases of a given NFPV exceeds the availability of seed units of that variety in the real world, he can define to whom he awards them.
- In the case of the acquisition of copies of the NFPV, the breeder of the world variety may apply the optional exception mentioned in article 15.2 of the 1991 Act of the UPOV Convention.
- The transparency of the NFPV surpass any kind of real-world seed transaction today.

VIII. ENFORCEMENT

As for point 7 of the previous section, the issue is how to enforce a smart contract for the case of a NFPV.

On this regard, intellectual property, and technological enforcement through authentication on blockchain involves using blockchain technology to secure and verify ownership of digital assets. This can include using blockchain to store and track the ownership and transfer of NFPVs representing the tokenization of a real-world plant variety.

The decentralized and immutable nature of blockchain provides a secure and transparent record of ownership, making it more difficult for intellectual property to be stolen or misused. This approach can be combined with digital signatures, encryption, and other security measures to provide a robust and tamper-proof system for enforcing intellectual property rights.

IX. TNFPV, COPYRIGHT, TRIPS AND UPOV

This work proposes the creation of NFPVs for the commercialization of seeds of protected varieties by their breeders and constitutes an unpublished and original scientific work registered in the Copyright Office of the Argentine Republic under Law 11.723 [46]. By the intellectual property rights conferred, the authors are the only ones authorized to exhibit or reproduce it by any means, translate it, exploit it commercially or authorize others to do so. It also allows them to prevent any unauthorized person from exercising these rights [47].

By means of the Law 25.149 the Argentine Republic has ratified the Berne Convention for the Protection of Literary and Artistic Works. Due to this, works originating in one of the Contracting States (that is were first published there) must be subject, in every one of the other Contracting States, to the same protection that they grant to the works of their own nationals (principle of "national treatment"), and such protection must not be subordinated to the fulfillment of any formality (principle of "automatic" protection) [48]. This means that the territoriality of the rights of this work reaches the 179 Contracting Parties to the Berne Convention.

This protected work also has its own NFT [49].

This work is not proposing the registration of the genetic code or any kind of genetic information of the real-world plant variety or its NFPV as a copyright, as it has

been previously formulated [50] [51] [52]. On the contrary, what is proposed in this work is the creation and commercialization of the seed of an NFPV, a concept that is perfectly in line with TRIPs, which mandatorily requires its member states that plant varieties (reproduced by any type of propagation system) must be protected by an effective sui generis system. Nor does this work conflict with the UPOV Conventions or the new protection systems proposed, since they deal with the effective protection of plant varieties, but not with the seed trade.

X. CONCLUSIONS

The TRIPs obligation that plant varieties must be protected in all member states by an effective sui generis system has not always been fulfilled. This is largely because the various Member States have not been able to transpose into their national legislation concrete measures for the proper enforcement of breeders' rights.

Since, on the contrary, TRIPs do not make it mandatory for member states to use the UPOV system, this leaves enough room to devise new ad hoc legislation, or to create other sui generis enforcement systems.

The creation put forward in this work of developing a blockchain smart contract to help ensure transparency and formal creation of Non-Fungible Plant Variety (NFPV) by tokenizing such a real-world asset, is original in every way. Moreover, it enables complete transparency of the seed market by establishing an unprecedented relationship between the breeder of the plant variety and the acquirer of the seed of the plant variety.

Although the creation and commercialization of NFPV seed can be applicable to any type of crop, its relevance to specialty crops is evident.

In today's world there are challenges for the management of intangible assets. This work establishes a guideline that can be followed to strengthen a model for the protection and development of innovation. Clearly, the technological advances of recent times (Blockchain, Metaverse, Artificial Intelligence, Web3, among others) will converge to develop a new ecosystem of relationships.

The central idea is to establish a value capture scheme that allows to face the challenge of new technologies and thus, solve some deficiencies of the real world, making possible to establish a management base in non-fungible tokens and make users' movements and transactions transparent on the blockchain.

Certainly, it is possible to foresee some shortcomings that need to be perfected to have a complete model, such as governance structure, management oversight and decision-making power within the organization.

Even taken such issues, however, this proposal is the cornerstone towards the creation of an innovative intellectual property management model to control seed trade of protected plant varieties.

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