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ACTUAL STATE OF DEVELOPMENT OF AN INTEGRATED TECHNOLOGIES TO PRODUCE PLUG TRAY SEEDLING IN ADAPTIVE NUTRITIONAL FILLINGS

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Abstract: In this paper will be presented some of the most innovative integrated technologies and also an experimental model developed in INMA, dedicated to produce high quality seedling in plug trays in which the germination layer provides an adaptive nutritional soil to every agriculture sector (forestry, horticulture, vegetable crops). The utility of this material is to present some integrated seedling technologies is for farmers to orientate rapid toward technical solutions, in accordance with their need, so to increase productivity where the human work is poor, and to deliver high guarantied quality seedlings in critical periods (where metrological instability makes disasters in the fields and greenhouses). So, an investment priority is nowadays necessary to predict and some funding, in addition to restoring greenhouses, solariums or other infrastructure elements, is to purchase of good quality seedlings in the shortest possible time to return to the market with quality products.

Keywords: mechanized seedlings, integrated technology, plug trays, adaptive nutritional fillings, sustainable agriculture, pneutronic seedling technology

1. INTRODUCTION

The automatic nursery pot lines, nowadays is a subject of grate interest for farmers (vegetable and horticulture seedlings producers) that leads to maximum capitalize the seeding materials if it is correct seed in an adequate substrate. So, preparing custom crop soil mixes and fillings is an important and complex detail that can determine the automation grade of a plug tray seedling integrated technology. This lines and technologies usually are farmer custom made and in the same tine also system automation complexity and technical configuration accordance with his requirements. Usually, a basic sowing line is made from, a tray supply and packing line, a plug tray sowing equipment equipped with seed feeder and piking system, for preparation of the plug filling is usually made manually–manufacturing process, buy a human operator, nowadays human resources is hard to find and unreliable. Therefore, the development trend in this field is to automate the production process, starting from the preparation of the planting substrate to obtaining the seedling. So, the system configuration is influenced by: the plug trays dimensions, sowing seeds equipment's configuration and automation, watering and transport lines technical configuration, and the plug filing preparation and dosage system.

In the EU strategy one direction is toward – "Automated steering systems, which can take over specific driving tasks such as auto–driving, following field edges and overlapping of rows". An advantage that brings it is reduce human errors, contribute to effective soil and site management, reduction of fuel consumption.[1]

If we seek to implement the autonomous agricultural robots that can be able to reconfigure their own, in accordance with a preestablish architecture it will be possible to perform various tasks and offer an enormous potential for sustainability.

From our point of view this direction aligned with our research in the next direction:

— reduce human work effort and resources input, because the fully automated technology/robots will most likely provide greater output, less unpredictability, more availability, multitasking works, as they already do in the automative industry.

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— fully automated technology/robots will optimize farmers inputs management (fertilizers, fillings, seed, seedlings, water, pesticides, insecticides) and reduce safety requirements form dangerous human health conditions (dust, chemical substances and gases).

Food security and food safety can be easily achieved applying and combining some innovative and integrated agricultural strategies in regional area, to rich global food and nutrition security by 2050 and agricultural global Total Factor Productivity (TFP). This factor represents the percentage between the EU total outputs to the total inputs used for food production; the target was set at a growth with an average rate of at least 1.8 % per year. According to the European Commission's DG Agriculture (DG AGRI) – based upon Eurostat data – TFP growth in EU agriculture has constantly remained below the percentage needed by the EU to contribute in a meaningful way to global food security.

Another important aspect to generate sustainable productivity is the management of the Nitrogen–uptake rate (the amount of Nitrogen applied in a field that is actually absorbed in the plant). Usually in field crop conditions, the maximum Nitrogen uptake can rich 50% and the rest ends up in the air, the soil or the ground water, so means 50 % are wasted. By applying innovative plug tray seedling technology, can provide a crop dedicate plug tray filling mixture, so to apply better inputs management and generate optimal filling composition (soil/peal, water, NPK fertilizers, etc.) after compounds were tested and based on this can be made an agronomic recipe. To reduce the waste rate, after the plant is taken out of production, the fillings can be reused, so the nutrients that are lost in the soil and ground water can be recovered successfully. In this way, the nutrient inputs and the losses are reduced, the precision agriculture (PA) productivity and sustainability is increased and environmental impact considerably reduced.

Biond human/technical resources and costs, the EU commission identified another important aspect that farmers have to face it, risk–taking attitudes that in these days is lower, due to an increased conflictual state, social and environmental instability (drought, floods, hail, pests, reduced accessibility to inputs, devaluation, world market instability and predictability, etc.) should be rewarded so that progress disseminates among farming communities

2. MATERIALS AND METHODS`

This subject is widely debated and the complexity is large, because of its importance and technological development trends, form this reason was made a schematic overview divided in modules that in some publishing papers works are interconnected and interchangeable.

In order to make a schematic overview of the complexity of this subject, was made a basic diagram in Figure. 1, in which is represented the minimum interconnections and tasks. Some integrated plug tray technologies, presented in scientific publications, presents only the module 1 and 3 that are interconnected with a rubber transporter line, so have a lower complexity and the farmers must handily made the processes described in module 2 and 4. Also, for example, sometimes the watering installation, mentioned in 4^{th} module, can be included in the filing preparation system, included in module 2^{th}. This change is due to filing preparation technologic point of view, usually the filings are made mixing blond with brown peat [2], the ratio depends on crop specifications. Moreover, from our experimental experience, this substrate has grate elasticity, when the blond peal has the largest ratio, and the seedling machine has a small precision [3], the seed position is easily influence by the vibrations from the processing line, this phenomenon can be avoided by combining two processes: the process of reduce peat fibber length crushing and increasing its humidity.

Appling those phases in peat processing lines the filling has: high malleability when is administered in plug trays; reduces the water evaporation rate; increases the mixing performances; increase seedling precision, etc. But, if it is taken in to consideration the agronomic aspect, the watering phase is also necessary after seeding procedure and added another filling layer, in order to

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achieved a maximum contact surface between seed and plug filling, in this way the germination process starts as soon as possible, if the favorable environmental conditions (humidity, temperature, good sunlight and adequate nutritional substances –NPK fertilizers). [2]

To design and develop a dedicated seedlings plug tray technology is complex multi factor decision making strategy, but in this paper is made a simplified diagram about it, see Figure 1, but the most important aspect in this activity is the collaboration of mechanical engineer with an agronomic expert, in order to check and validate the modules and the right equipment's/machines/units unframed in the modules (activity represented with yellow arrows), but also the technology design:

1. Design a flow chart of the technological processes and establishing its working parameters (plug tray model, humidity, displacement velocity, working volumes, sowing seed no., water flow, etc.) in accordance with crop specification (vegetable, flowers or forestry);
2. To select the adequate equipment's, installations and machineries, that can be integrating in the modules presented in from Figure 1, which can fulfil the technical parameters established at point 1;
3. To design a command–and–control sequence, in order to synchronize and correlate in a logical sequence all working parameters, as it is illustrated with red arrows in Figure 1, each red shade represent a factor influence upon each module;

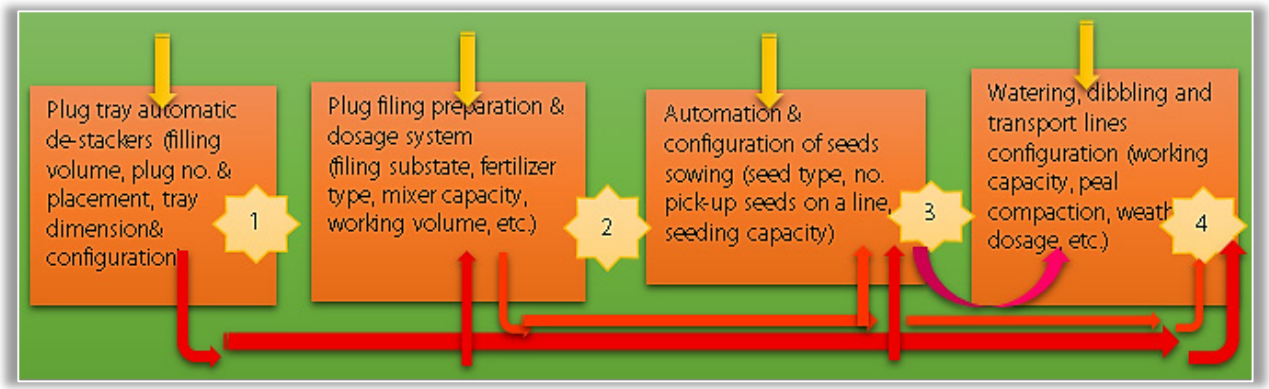

Figure 1. A basic flow chart of the plug tray seeding technology and its complexity

In practice, the design of plug tray seedling technology must take in to consideration many other factors as: technology system adaptability to: technology location – implementation area dimensions (industrial hall LxWxH) [40,41], available budget, implementation period, type of crop/crops[42],number of operators, connection to energy and water installation, maintenance, etc. [43]. Another important aspect, which influence the cost and implementation period, is the automatized process level and remote/local control program & devices (industry 3.0, 4.0 or 5.0). [4–6]

3. TECHNICAL MODULES DESCRIPTION AND ITS ACTUAL STATE OF DEVELOPMENT

The design activity of an integrated technologies to produce plug tray seedling in adaptive nutritional soils is relatively new and can be used in dedicated crop so, to fulfill the both agronomic and technologic strategies. The collaboration between an industrial development and agronomic engineer is essential because the plug tray seeding technology must comply: unframing in the optimal germination period; preparing the adequate sowing layer/ plug filling in accordance with seed/crop germination requirements (humidity, soil type, light, heat, NPK concentration, etc.); storage and monitoring conditions.

- The Module 1 – Plug tray automatic de–stackers. As is well known, the plug trays can be all shapes and sizes, from very small cells (1 cm) to quite large (6 ÷ 9 cm plus) – choosing these trays depends of crop seedling agronomic aspects (seeding earth volume, seeds no., rooting network, etc.) and agronomic plant development stages. The small dimension plugs are usually

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used for small seeds, in this way its conferring optimal conditions are ensured for the germination stage and development of the first leaves, for each seed, preventing the diseases spread and easy monitoring productivity. But also, it is necessary to replicate/transplanting the plug in to next dimension for development continuation until reaches the seedling stage. So, the more transplanting trays, the more expenses, especially if it is used a plug extracting machinery (replication machinery that is not mentioned in the present technology– these machineries are in development and research stage until now). [7] Another economic aspect that must be taken in to consideration, is the plug trays manufactured materials and there wall thickness that can be from 0.6 until 1 cm. Very thin plug trays can be used 1 or 2 years, but they also need a carrying tray to support them, on the other hand, the thicker ones can be used for 3 until 4 years and can be subjected to sterilization processes. [8] A general overview of plug tray and its classification is made in Table 1.

Table 1. Plug tray classification – commercial models [9–14]

Plug name	Plug formation	Plug dimension & specifications	Plug tray plant specifications
Small plugs / germination cell	Trays 128, 105, 98, 72, 50[3*] Plug tray setup: arrangement in rows and lines [2*] Plug geometry: conic, pyramidal trunk, hexagonal shape Material: PP, PS, PVC, Biodegradable, Thickness: 0.6÷1 mm	A square surface of 1,5x1,5cm & 2.5cm deep Compost volume/plug: 5,625 cm[1*]	Secure rooted, strong plants, Foliage height 1.5 ÷ 5 cm Protection from frost. Need to be transplanted and grown on a windowsill/ greenhouse/ conservatory, before planting out ready to flower.
Value plugs		A square surface of 2x2 cm & 3 cm deep Compost volume/plug: 12cm [1*]	
Medium Plugs		A square surface of 2,5 x 2,5 cm & 3.5 cm deep Compost volume/plug: 21.875 cm [1*]	
Extra/Large Plug	Packs of 3&5 Trays of 28, 84, 104[3*] Plug geometry: conic, pyramidal trunk, hexagonal shape Material: PP, PS, PVC, Paper, Thickness: 0.6÷1 mm.	A square surface of 3x3 cm ÷ 4x4c m & 4cm÷5cm deep Compost volume/plug: 36 cm ÷ 80 cm[1*]	Pot Ready, Large, Healthy plants, individually rooted. Ideal for planting into baskets, containers or small areas in the garden. Foliage height around 5cm–12cm (depending on variety).

*The main working parameters that will be introduced in other modules: [1] compost; [2] plug tray mesh; [3]plug cell no.

Table 2. Plug tray de–stackers equipment's –some industrial models. [16–18]

		
Urbinati automatic de–stackers	Versa Tray/Pot De–stacker MHD–LB model	Tray de–stacker from Filler Systems
– modular composition; –automatic system for trays, pots and shuttle trays; –CCU with PLC and data display on touch–screen panel; –modular structure from 1 to 6 de–stackers. –Belt width (standard) L = 450 / 600 mm; –Frame lengths (standard) L = 1300/ 2300/3300/4300/5300/6300 mm; –fixed–speed conveyor belt; –container with photocell and/or laser presence detection; –adjusted production based on the final configuration required; –available in right or left side operator version.	–short/long tray de–stacker; –places the pots into the tray, working capacity up to 8500 pots/ hour; –tray/pot de–stacker contains an innovative lifting unit; –lifting unit lowers the dispensers' frame, to position it precisely into the trays; – tray/pot de–stacker can be using different size trays and both round and square pots. –this multi–head pot dosing device can be adjusted to fit your operation. –well–organized control panel, the operator can easily program several different kinds of trays and dispensing programs.	–models available depending on the type of tray; –the weight of the trays and the desired height of the stacks. –available for almost any type of trays; –suitable for heavy stacks of trays (heavy–duty); –can be used for both stacking as well as de–stacking; –process jammed crates during de–stacking; –optional door to prevent trays from toppling over.

In commercial used, can also be find, also a special plug tray designed is made for plants with deep roots, it is often called root trainers, this option can be a good choice for vegetables and perennials plants. In table 1 are also mentioned the working parameters that define the plug tray sowing

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technology: compost volume prepared and dosed by equipment's unframed in module 2; plug tray setup and dimension which define the sowing equipment's type from module 3 – especially the seed pick–up device, displacement step, no. of seeds placed un plug, and also the design of devices from module 4 (filling/compacting heads and watering devices of seedling bed). Plug cell no./seedling tray is also an important criterion for defining the seedling head (the no. of seed manipulated lines or nozzles) and also the module 4 configuration. [15]

The plug tray de–stackers at this moment most popular models commercialized are the automatic ones, see Table 2, but also are many others models that have larger dimensions and high productivity. To chose one model it necessary to establish the plug tray dimensions, material resistance and weight. Some times this equipment's can be adjusted accordance with plug tray type, models with more versatility.

- The Module 2 – Plug filing preparation & dosage system. Nowadays, the farmers, make the plug tray filing manually, using shovels and human work. Until now, where identified soil management equipment's only for open field conditions, and from my point of view, until now this system is not yet developed as an integrated equipment. So, in the figure 2, it is be presented a schematic system configuration that can be easy designed and modify accordingly with farmers resources, necessities and outcome/goals (bio/ ecologic/chemical treated crop) using components and machinery from different manufactures that can be put together with the help of specialized engineer.

The filling mixture composition is made, according with crop seedling specification, using a sterile soil mixture (% blond peat + % dark peat), a fertilizer % (manure/NPK fertilizers) and a moisture–absorbing compound (bio–char/ Eifel Primordial Rock Lava Granulate/Terawet polymeric superabsorbent/etc.). The mechanized equipment from soil management can also be acquired from continuous seed processing equipment's (continuous helical and pallets conveyors with different constructions) and food industry mixing machinery (batches helical belt/ belts conveyors). For applying and dosage of water/bio–fertigation/fertilizer solutions can be used nozzles irrigation systems connected to peristaltic/membrane pumps that drawn liquids from a tank. In case are used liquids with suspensions in supply tank must be used an agitator that also is need to be connected to central control unit – CCU.

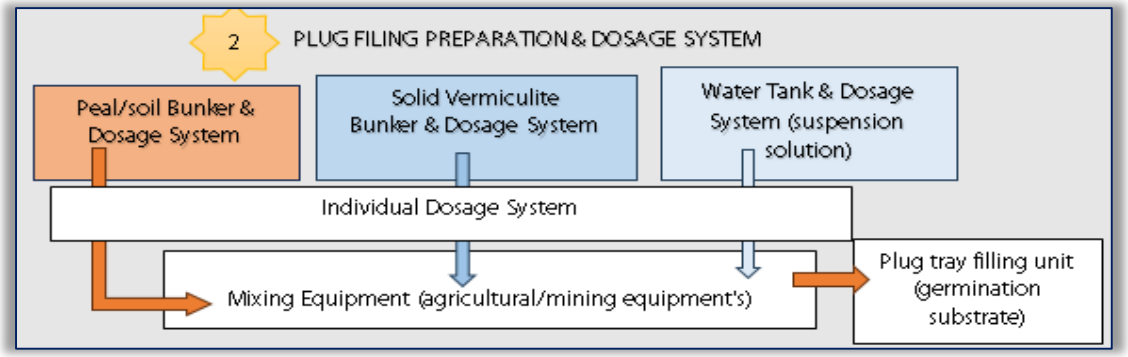

Figure 2. Schematic general configuration of Module 2.

The plug tray filling substrate must comply with a certain recipe, so the required mixing rate and humidity are reached using an individual or centralized dosage system, also mixer capacity and flow assure the filling quality and continuity. The components are usually administrated from classic bunker constructions, using a central/individual dosage system that receive signals from a CCU on which is set the filling recipe. Sometimes, the solid NPK fertilizers (compost, bio–char, or a combination of them) and Bio–fertigation bunker is required to be placed in open spaces, because can generate operators' dangerous gases and highly flammable gases, for this reason the individual dosage system can be placed on bunker, instead for the rest can be centralized.

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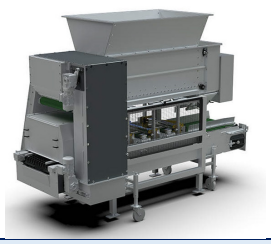
Form peal administration considerations, in literature is specified that, the granulation must be less than 5 mm, and for the same reason the integrated dray digested compost granulation/biochar is necessary to have the same dimensions so, the composition to fill even the smallest plug trays. Plug tray filling unit is an essentially industrial equipment of this technology (some of the most popular industrial models and their technical sheets are presented in Table 3), because it correlates the plug tray transportation line speed with mixing unit filling flow and working capacity, from this point on the tray is directed to module 3.

Table 3. Plug tray filling equipment's –some industrial models. [19–21]

		
Urbinati RC65 Plug Tray Filler	Versa Filler	Demtec KV98–tray filler
–filling polystyrene trays, plug trays or shuttle trays; –it's also capable of filling individual thermoformed trays; –production up to 600 trays/hour; –inclusion in a transplanting line, seeding line or just as a standalone tray filler; –adjustable speed conveyor belt; –hopper capacity of 800 liters (optional 1100 liters) with a conveyor belt at the bottom; –buckets chain elevator to avoid damage compost granulation; – adjusted filling density from control panel; –cylindrical tray cleaning brush; –electric panel start/stop/emergency and limit switch; –installed power 3KW 3F 400V 50/60Hz –equipment weight 585kg; –CE conformity.	–most advanced & versatile filler model; –fully adjustable to your container, plug diameter, filling density, and required capacity; –filling plug trays with high speed 500 trays/hour; –perfect and homogeneous soil compaction using five exchangeable processes; – 400 mm high and 600 mm wide trays, capability to fill long–side leading; –all working parameters are manually height/speed adjustable; –10 air nozzles are used for soil removal, making for a clean operation; –1000–liter capacity hopper; –hopper extension is optional to increase the volume to 1850 liters. –the soil elevator is manually adjustable flow.	–the filler is a very fast, robust, flexible filler. –filling trays up to 42 cm wide and 23 cm deep; –the density of the fill can be controlled from the control panel. –filling substrate capacity can be adjusted in accordance with trays/large pots volumes; –presents a complete soil recovery system with powered rollers (no. spillage or wastage of compost); –can be used also for transplanting line filling packs, but also as a standalone machine filling troughs or pots.

The tray fillers can be used as standalone machines or added into an automatic seeding lines controlled from a dedicated CCU (as it is presented in Table 3, some machines have manual working parameters and for this reason is hard to integrate in a fully automation line). A technical advantage of this model is the option to be supplied as single or three phase fillings (in accordance with customer requires).

The Module 3 – represents the all types of plug tray seeders. Surfing through the functional models of plug tray seeder, it was concluded that, their evolution has stagnated and the marketed models fall into three categories: handy instruments, semi–automated and fully–automated. [22–24] The equipment's that can be successfully integrated in this kind of technology are the fully–automated, and in some cases also the semi–automated, but the working technology methodology, must be adapted to those machines (integrate an adjusting and verifying phase in the technology operating mode, even if it is modified only one parameter, phase that requires raw materials and time), more than also require increased and distributed operators attention during operation mode (the involved operator no. depends on no. of manual equipment's) in case of equipment's does not function properly or a malfunction occurs. For each machine plug seeding equipment category will be presented a beef technical description in Table 4 of most performing equipment's.

Most manufactures are customizing their seeding lines and automatic seeders by working in contact with customer, in order to comply their requirements (customized to partner business needs) and adapt to any seeds size and trays types. The modular machines, have a grate technical advantage because, because it can used multiple automatic sowing solutions such as: drum seeding, row seeding or plate seeding lines. The drum seeding lines can be accessorized with single,

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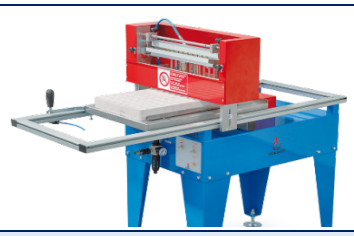
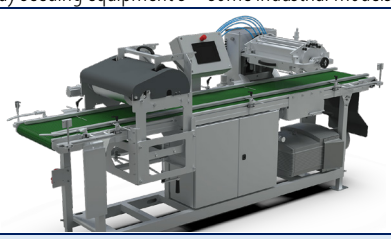
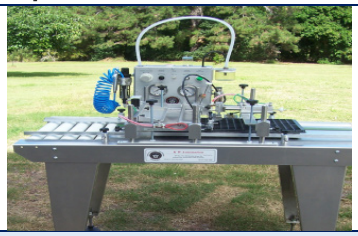
double or triple sowing heads. Urbinati models can also be configurated to offer ad hoc solutions, seedlings production using non–standard seeds (large seeds – for forestay and pomiculture sector) as volumetric seeder.[28]

Table 4. Plug tray seeding equipment's – some industrial models. [25–27]

		
Urbinati SEMSF13 Plug Tray Seeder	Viscon Roulette XL seeder	100 EM Seed–Air–Matic
– seeding productivity 1700 rows/hour; –seeding using a bar with nozzles which suctions the seed and deposits it in a precise and uniform way in the cells, row by row; – the hole is made in which the seed will be accurately inserted; –silicone nozzles, with 1.0 mm or 1.5 mm hole diameter; –nickel–plated brass nozzles for multi–seed from 2 to 8 holes: the diameter varies according to the combination chosen (diam. of holes from 0.15 to 0.70 mm); –single–hole nickel–plated brass nozzles; available diam. 0,15 – 0,20 – 0,25 – 0,30 – 0,35 – 0,40 – 0,50 – 0,60 – 0,70 – 0,80 mm. –semi–automatic machines operated with compressed air through a pneumatic system, – working for single trays handled by the operator. –excellent flexibility of use thanks to the easy seeding nozzle changeover, suitable for both small and large seeds.	–horticultural production seeding innovation; –fully automatic drum seeder with a high capacity; –unique drum that can seed the most difficult seeds; –sown at high accuracy of 99%; –settings per tray or seed type, are stored in the computer; –all settings are constantly monitored and controlled for optimum seeding results; –all settings can be programmed and saved by the operator using the touch screen display; –programs no. can be saved on the computer is unlimited; –seeding line with other modular components such as a tray de–stacker, tray filler, watering tunnel, covering unit, and a tray stacking unit; –tray dimension 600x400 mm; –separation comb for extra accuracy; –servo driven dibbling unit; –second servo driven sowing set –productivity 1500 trays/hour.	–quickly and easily change seed types, tray configuration and different size needles; –high–pressure push–button needle cleaning; –sows seeds of all shapes and sizes; –high volume precision seeding to the grower; –light or heavy covering of either vermiculite or dry plug mix as required; –optional watering bar is also available which gives the grower the ability to accurately inject controlled doses into each cell at various stages of seeding; –different sizes of seed suction needles allows seed of all shapes and sizes to be sown (including Raw Petunia, Marigold and Tomato). –seeding directly into flats or plug trays singly or in multiples can be carried out simply by replacing single needles with multiple needles (up to 4 per cell). –utilizing our revolutionary needle system, allows the sowing of even the most difficult seeds.

- The Module 4 – Watering, dibbling and transport lines configuration (working capacity, weather dosage, etc.) In this module were included some optimal equipment's as watering and dibbling units that can be placed up one the transport lines. The necessity of this units is justified only, if the trays seeders are not acquired with this units, in that case the sprinkler must be synchronized with tray speed, plug dimension and seed germination conditions (the filler humidity from the mixing module).

The dibbling units/equipment's are having different dibber systems as: dibbler plate with pins (NI)/rotating pins (NPR)/drills (NIR), see Table 5. Those models are usually tailor–made according to customer needs, is easy to replace thanks to the sliding support guides and the dibbling depth is easily adjusted with a simple crank. Like the others equipment's, also can be used both as a stand–alone machine and inserted in a working line thanks to the conveyor belt feed system.

Urbinati company, offers a series of automation machines customized to customers handling process necessity for greenhouses and nurseries conditions. Those models are versatile and customizable in order to easy comply to the needs of both small and large productions.

On the market are present a large typologies of aluminum or steel modular conveyors, Tabel 6, powered by belts and chains, configurated to handle pots and trays, automated palletizer for containers on pallets storage, buffer tables for the pots and trays grouping or separation and finally the automatic trolleys and frames loader that takes care of storing half–shells, trays and containers on the shelves of standard CC trolleys (danish trolleys), out of standard or customized racks.

Another technical option is to acquire plug tray transport lines are thus with rubber and roller band, because can provide a secure, durable and easy to clean solution in hard working environmental (dusty, high humidity, and high human safety conditions).

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Table 5. Plug tray dibbling equipment's – some industrial models. [29–31]

	
Urbinati plugs tray dibbling unit	Viscon dibbling unit
–models with pins (NI)/rotating pins (NPR)/drills (NIR); –productivity 800/600 containers/hour; –containers positioning with double block; –sliding guides to support the dibbling plate; –easily adjustable dibbling depth; –fixed rotating pins speed (NPR); –belt length (standard) L = 2300 mm; –fixed speed conveyor belt; –available in left and right version; –plate and counter–plate custom made; –plate with rotating eccentric punches; –electronic speed variator for advancement belt; –conveyor belt length available in the following versions: L = 3300/4300/5300/ 6300 mm; –tray holder, with fixed or adjustable tilt table; –wheels kit for handling.	–drilling units can be used for three applications; dibbling, drilling, and eccentric drilling. –Dibbling can be done via a mechanical plate or a drum. –The units are modular built and available as stand–alone or inline versions: dibbler plate, drill unit and eccentric drill unit; –all types of trays are compatible with the machines and that high capacity is guaranteed; –drill unit into trays and pots. –eccentric drill unit for drilling (transplanting) holes into trays and pots. –its equipped with a switch box with a programmable digital display allows for easy adjustments. This makes for a smooth operation.

Table 6. Plug tray conveyors – some industrial models. [32–34]

		
Urbinati rubber belt conveyor NTV	Plastic roller conveyors	Painted steel flexible conveyor
–Special profile painted steel structure. –Double polyester cross–weave PVC belt, sliding on a fixed surface. –Belt width: 700 / 600 / 450 mm. –Frame lengths available in different standard solutions; –Fixed conveyor speed; –230/400V three–phase power supply.	–roller conveyors with Ø 1 7/8" plastic rollers; –versatile conveyor type for many applications; –gradients of 2.5 ÷ 5 % ensure unassisted flow of products depending on type; –easy and quickly extended, changed and moved; –axle pitch can be changed without the use of tools; –silent system with very little friction; –the conveyors have smooth way frames with no sharp edges.	–SEW Eurodrive AC Motors – Conveyor speed is fully adjustable from 10 to 40 m/min; 0.09Kw for 230V 3Phase, 50Hz supply; –Roller centers 125mm as standard when the conveyor is fully extended; –Optional 75 mm and 100mm roller centers can be supplied for the conveying of smaller packages or cartons.

The watering dosage units/ sprinkled installations usually are custom made by the dedicated here in presented companies and are placed after the seeding unit on the conveyor structure, controlled individually or CCU. Another option, is to buy a commercial sprinkled installation that can be easily controlled thou most innovative modules (on board control unit or wireless phone application).

Finally, the vermiculite/filling covering and watering unit complete the seeding cycle, while the stacking unit, with the balance stacker, sorts the newly seeded containers in orderly stacks to make it easier to extract or palletized them.

An integrated plug tray sowing technologies marketed by here in presented companies. For example, Urbinati KAPPA65C technologic model, Figure 3, is also another option for those with financial resources and a growing seedlings market demand. The sseedlings line has the next components: 1– pneumatic tray de–stacker for polystyrene trays with two directions; 2– hopper capacity 700 liters and conveyor belt with rollers on hopper's bottom; 3– width 500 mm double chain soil elevator; 4–tray filler with 4 blades longitudinal rotor, with rotation reversing gear; 5–double auger spillways with motorized brush for tray cleaning; 6– automatic pitch seeding head, dibbling device included; 7 – control panel with 5.7" color touch–screen; 8 –100 liters covering unit

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for vermiculite, with adjustable speed and dosage; 9 – 250 mm length watering unit with drilled bars module; 10 –stacking unit, with balance stacker; 11 –longitudinal tray advancement unit.

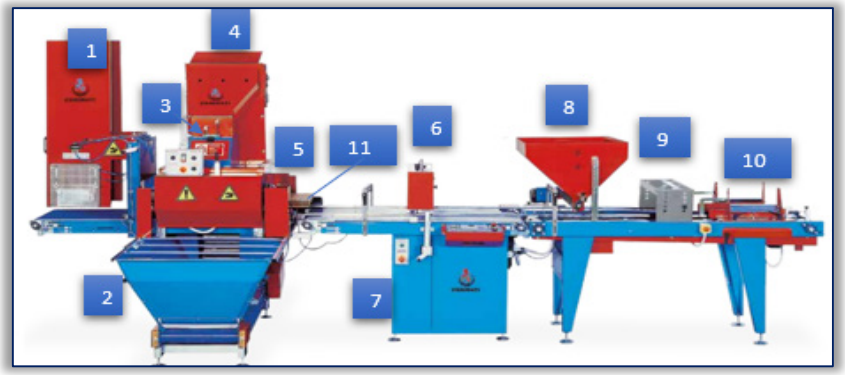

Figure 3. Urbinati complex seedling line structure –KAPPA65C model [35]

Usually, all equipment's presented are electro–pneumatic actuations systems, because presents non contamination mechanism, with high compliance and easy to configurate powering systems, and also the compress air is a regenerable and easily accessible resource for mobile and stationary technologies. The pneumatic control and measuring devices can be easily connected to a programmable CCU. Therefore, the plug tray technical solutions development trends of an integrated technology fall within the principles of pneutronic actuation systems, especially for the module 2 – Plug filing preparation & dosage system, that gains more interest in the PA domain, if we take in the consideration the bio–fertilization research developments (biochar agriculture technology developments, especially farms biochar production and capitalization).

3. RESULTS

Aligning with in new PA trends and farmer's needs, in context of sustainable and circular agriculture, was detected a niche field, capitalization of the NPK bio–fertilizers and seed potential, in the green and nursery conditions, by developing an innovative pneutronic plug seedling technology. This research activity has a win –win character, because until now the biochar field research activities are directed toward carbon sequestration aspect, due to the fact that the field biochar administration (do not registered high productivity) so the green biomass capitalization do not resister high NPK concentration, compared to that obtained from manure.

This concern is justified also, by continuation of the INMA research projects and performance improvement of the pneumatic plug tray seeding equipment, [3] which depends also by the quality of tray fillings, especially of mixture mechanic properties (granulation, humidity, composition, filling elasto–plasticity, etc.).

In this chapter is presented a schematic view of this concept, on which we are currently working and were obtain results by designing patented innovative equipment's, that can be successfully integrated in module 2, see Figure 4.

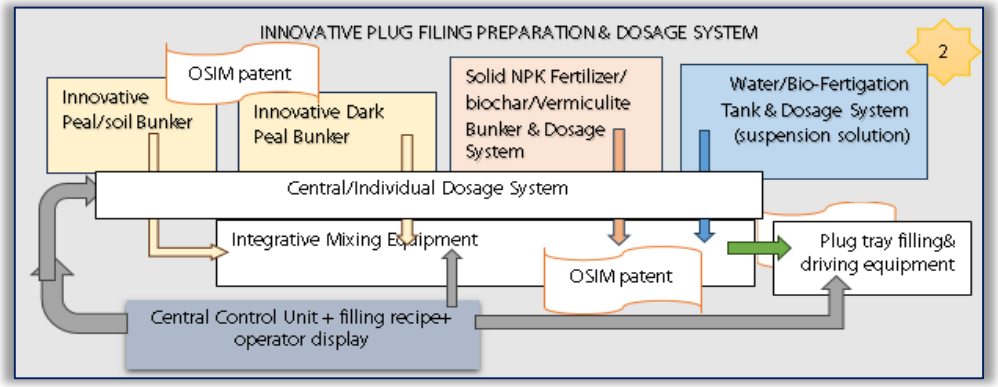

Figure 4. Pneutronic plug tray innovative technology – plug tray filling and dosage module.

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In the mechanization industry the integrated mixing equipment's for high humidity are a few models, generally horizontal conveyors (helical spiral, tape and pallets). Analyzing their constructive advantages and critical points, was designed and patent an Integrated Mixing Equipment [36] to be safely used in such of complex granular applications using all three principles because, it is needed an conveyor (helical spiral) an mixing unit (tape helical spiral) and a high humidity material removal system from the conveyor casing (rubber palates/fingers) placed on the spiral tape, also in this way can be reduced the blockage risk and losses minimizing. Another, special element of this model, is the granular material administration funnel of the integrative mixing equipment, so that the feeding funnel must be configured so, that the three major solid components (powdery/granular mixing components: for blond and dark peal, solid synthesis NPK fertilizers/biochar/compost) can achieve the optimal composition selected from operator display which is in connection with the innovative bunker [37] powered by Pneumatic Artificial Muscles that can be used for any type of granular feeding material in this module. This germination filling recipe is mandatory to fulfil also the water % and also the bio–fertigation solutions dosage which can be administrated through a nozzle installation that is usually placed on top of the conveyor. The mixed filling is lead to a plug tray classic filling unit corelated with an innovative pneumatic tray conveyor or dedicated ones with adjusted transition step [38].

The CCU is interconnected with all active equipment's and systems, in its configuration can be also included signals form peal/soil humidity and level sensors, water and bio–fertigation level sensors and temperature. According with singles collected the pneutronic equipment can be power at optimum working set in the technologic working program. Programming this unit must have an architecture specific to multi–decision systems, on layers, and also continuous acquisition data, this aspect will be further developed and presented in dedicated scientific research papers.

4. CONCLUSIONS

An important aspect, from configurating the plug tray seedling technological line, is to acquire the equipment's from the same manufacturer, in this way the customer can negotiate an advantageous package (a custom plug tray seeding technology; a better acquisition price; an equipment/part maintenance and guaranty package; and sometimes software upgrade and assistance) at an advantageous price.

Unsing This type of technology from agronomic point of view, increases production rates and improves plant/crop uniformity, by ensuring consistent soil nutrient levels and compaction. Another aspect that is mentioned by other researchers, is the reduction of the spread of plant diseases, that can be implemented by PA dedicated systems.

From technologic point of view, taking in to consideration the multitude of solid fertilizers (biochar–based fertilizers, vermicompost, etc.), types of inhibitors, liquid biofertilizers and seeds types (treated, metered, glazed, etc.) the necessity to develop this plug tray filling and dosage module became a necessity in order to conduct bigdata research activities and also commercial dedicated technologies to capitalize all agricultural inputs. From this point of view, the key equipment includes soil mixers, conveyor systems, and automated potting machines that dispense soil and create custom growing media.

Plug tray seedling technology is widely utilized in protected agriculture environments (greenhouses, nurseries, and healthy plant material selection farms) due to its high germination rate, neat growth, seed–saving benefits, and suitability for mechanized operation [13]. After a period of growth in a plug tray, the seedlings must be picked, replanted, transplanted, and sorted to foster optimal growth conditions [14].

A better farm resource management (nutrient, soil, plug tray, water, light, water, etc.), high seedling yield of good quality within continuous production reflects the efficient resource utilization and minimal impact on environmental, are the key factors that makes it an excellent option for

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vegetable, horticulture and forestry crop production [9–11,39]. Further research will be conducted on working parameters flow chart of module 2 in accordance with all type of inputs required and establishing the particularity the innovative technology for each agriculture sector: vegetable, horticulture and forestry plugs or seedlings.

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