JUST AGRICULTURE
multidisciplinary e-Newsletter

Nano-Technology Vis-A-Vis Weed Management

Aabiroo Rashid[1], Aanisa Manzoor Shah[2], Tajamul Islam Shah[3], Amal Saxena[1], Tahir A. Sheikh[1], Ansar-ul-Haq[4], Zarka Nabi[5], Raieesa[2], Suffiya Wani[1] and Shabir A. Bhat[1]

[1]Division of Agronomy, Sher-e-Kashmir-University of Agricultural Sciences and Technology of Kashmir, Wadura-193201, JK, India
[2]Division of Soil Science & Agricultural Chemistry, Sher-e-Kashmir-University of Agricultural Sciences and Technology of Kashmir, Wadura-193201, JK, India
[3]Division of Soil Science, Sher-e-Kashmir-University of Agricultural Sciences and Technology of Kashmir, Shalimar-190025, JK, India
[4]Division of Agronomy, Mountain Livestock Research Institute, Sher-e-Kashmir-University of Agricultural Sciences and Technology of Kashmir, Mansbal-193504, JK, India
[5]Division of Plant Pathology, Sher-e-Kashmir-University of Agricultural Sciences and Technology of Kashmir, W
adura-193201, JK, India

ARTICLE ID: 39

Introduction

The term "Nano" is derived from the Greek word "nanos" meaning 'DWARF' (Small).Nano-technology, the science of very small things has been defined by US Environmental Protection Agency (2007) as a science of understanding and control of matter at dimensions of roughly 1-100 nm, where unique physical properties make novel applications possible (USDA, 2002).Nanotechnology has the potential to revolutionize weed management by providing new tools for controlling weeds in a more targeted and efficient manner. Nano-technology was introduced by Richard Fynman in 1960 and is an integration of various applied sciences like physics, chemistry, engineering, biology and medicine through which matter is either consolidated, separated or deformed to produce materials with unique properties like large surface area, progressive release and target site of action. The size of nano-particles range from 1-100 nm. They posses properties which are entirely different from the bulk material (Buffle, 2006). The properties of increased relative surface area and quantum effects make nano-particles significantly different from other materials. The nano-particles in current use include nano-rods and quantum dots, metallic & ceramic nano-particles, polymeric nano-particles, semi-conductor nano-particles, lipid based nano-particles, nano-emulsions and nano-encapsulations. The production of nano-particles involve

JUST AGRICULTURE
multidisciplinary e-Newsletter

two basic approaches i.e. top down approach (which means reduction of size of the smallest structures to the nanoscale, *e.g.* photonics applications in nano electronics and nano engineering) or the bottom up approach (which involves building up individual atoms and molecules into nanostructures).

Nano-particles exhibit certain unique properties which include:

- Morphology aspect ratio/size
- Hydrophobicity
- Solubility release of active ingredients.
- Huge surface area/roughness
- Surface species contamination/adsorption
- During synthesis/history
- Ability to produce reactive oxygen species
- Competitive binding sites with receptor, dispersion & aggregation

Applications ofNano-technology in Agriculture

Nano- technology has got enough use in agriculture starting from food production processes, encompassing food processing, packaging, transportation and consumption. Nano-technology can play an important role in:

- Precision farming
- Monitoring crop health and removing heavy metal contamination (through nano-sensors)
- Nutrient management (Nano-fertilizers)
- Seed technology
- Water management
- Food technology
- Plant protection (nano-pesticides)
- Bio-technology (nano-biotechnology)
- Weed management (nano-herbicides)

Role of nano-technology in weed management

Labour crisis and higher wages being paid to the agricultural workers have encouraged the farmers to adopt chemical means of weed management in their fields.

JUST AGRICULTURE
multidisciplinary e-Newsletter

Herbicides account for 47.5 per cent of the total pesticide consumption of 2 mt (Choudhary, 2020). No doubt weed management through herbicides is in vogue, but certain limitations like inability of a single herbicide to control diverse weed species, survival of underground propagules of weeds(tubers, rhizomes etc) to foliar herbicide applications, weed shifts, development of resistance by weed species towards herbicides, herbicide build up in soil and damage to succeeding crops etc co-exist, that can again put the farmers in deep trouble. Besides these chemicals also serve as a main source of environmental pollution. These problems could be better solved trough nano-technology which not only reduces the amount of herbicide used but also increases their efficiency.

Certain nano technology based intervention for weed control

1. **Destroying weed seed bank and killing perennial weeds**

The use of nano-carbon tubes to induce cracks in seed coat of weeds allows water chemicals to pass through them resulting in their prompt germination. Hence it disrupts the property of weed seed dormancy (which allows weeds to grow in flushes) and reduces weed seed bank. The germination is also enhanced by destroying inherently present germination inhibitors in certain weeds. For example the germination of tubers of purple nutsedge is enhanced when treated with nano-particles of iron oxide (Viji and Chinnamuthu, 2019) and zinc oxide (Brindha and Chinnamuthu, 2017) due to breakdown of phenols and other germination inhibiting biochemical components.The herbicide encapsulated nano-particles target the receptors of weed roots wherein they inhibit the process of glycolysis(e.g. silver nano-particles in Cyperus rotundus) thus reducing the food reserves of the plant which ultimately leads to death by starvation.

2. **Nano-encapsulation of herbicides to promote slow release**

In nano-encapsulation, herbicides are coated with an organic or inorganic polymer based semi-permeable membrane. The toxicant gets released through the processes of diffusion, ion exchange etc controlled by the membrane system. Encapsulation of herbicides with nano-particles ensures slow release of herbicides which promotes release of active ingredients in required concentration and for a required period of time to get the desired weed control. The release of active ingredients in nano-encapsulated herbicides is so controlled that it doesn't have any toxic effect on soil biodiversity and hence promotes sustainability of soil.

3. **Smart delivery of nano-herbicides leading to efficient weed control**

JUST AGRICULTURE
multidisciplinary e-Newsletter

Under moisture deficit conditions higher herbicide losses occur due to volatilization and photo-decomposition. Nano-encapsulated herbicides can prove helpful in such situations in improving herbicide efficacy. These herbicides are encapsulated within a polymer and release active ingredient only with the receipt of rain or when sufficient moisture is present thereby preventing losses due to degradation.

4. **Nano-encapsulations reduces herbicide build up in soil and discourages development of resistant weeds**

Active ingredient of a herbicide is delivered directly to the target site of weeds by using herbicides encapsulated with nano particles or using nano particles as herbicide carriers. This reduces the chances of herbicide build up in the soil. With smart delivery system a lower amount of active ingredient is required and the extremely small dimensions ofnano-herbicides allow it to blend with soil particles and prevent the growth of weed species that have become resistant to conventional herbicides.

5. **Nano-particles penetrate into plant cells very easily and exhibit faster movement within the plant cells**

Nano-herbicides penetrate into the plant cells very efficiently and are directly carried into the plant metabolic system, where produces malfunctioning in the targeted molecular pathways.

Conclusion

Weeds are menace to the crop production systems that not only reduce the crop yield but also reduce the quality of produce, cause wear and tear of farm machinery etc. Currently weed management is obtained through use of herbicides which no doubt are very helpful in achieving a good weed control but are accompanied by various disadvantages like the development of resistant weed species, build-up of herbicide residues in the soil, inability of a single herbicide to control perennial weed species etc. Nano-technology can pave a way out of this problem and help in cutting the losses due to weeds. It helps in overcoming the problem of perennial weeds by inhibiting growth of underground vegetative propagules by exhausting their food reserves, decreasing weed seed bank,breaking dormancy of weed seeds, improving absorption and Translocation of herbicides etc. The smart delivery system reduces the herbicide application rate thereby preventing development of resistance in weeds and also minimise environmental pollution and CO_2 emission.

JUST AGRICULTURE
multidisciplinary e-Newsletter

References

Brindha, K. and Chinnamuthu, R. 2017. Zinc oxide nanorods to degrade phenolics and stored starch of *Cyperus rotundus* tubers management. *Journal of crop and weed,***13(3):** 184–188.

Buffle, J. 2006. "The key role of environmental colloids/nanoparticles for the sustainability of life. *Environmental Chemistry*, **3:** 155-158.

Choudhary, SK. 2020. Novel nanotechnological tools for weed management–A review. *Chemical Science Review andLetter*,**9(36):** 886–894.

USDA, 2002. Nanoscale Science and Engineering for Agriculture and Food Systems. Report of Cooperative State Research, Education and Extension Service, USDA, National Planning Workshop, November 18-19. Washington, DC.

Viji, N. and Chinnamuthu, C.R. 2019. Nanoparticle effect on degradation of vanillic acid, a germination inhibiting dormancy factor present in *Cyperus rotundus*. *Indian Journal of Weed Science*,**51(1):**98-100.