Table1. Summary of different nanomaterials for mitigating abiotic stress.

NM	Conc.	Crop/s	Apl.	Abiotic stress	Effect/s	Ref.
Ag	0, 25, 50, 75 & 100 mg/L	*Triticum aestivum* L.	Soil	High temp.	Improved plant yield & growth.	1
Se	10 mg/L	*Sorghum bicolor* L. Moench	Foliar	High temp.	Enhanced antioxidant defense system, unsaturated phospholipids, pollen germination & seed yield.	2
ZnO	0, 15, 30, 45 & 60 mg/L	*Vigna radiata* L.	Foliar	High temp.	Increased chlorophyll, gas exchange & grain yield	3
MWCNTs & TiO_2	10 mg of TiO_2, 0, 10 & 15% TiO_2 + MWCNTs	*Sesamum indicum* L.	Foliar	High temp.	At different combinations & concentrations reduced H_2O_2 -. Increased oil content, unsaturated fatty acids &, seed yield.	4
SiO_2, ZnO, Se, & Graphene	300 ppm (SiO_2), 50 ppm (ZnO), 15 ppm (Se) &, 50 ppm (GNRs)	*Saccharum officinarum* L.	Foliar	Cold	Enhanced photochemical efficiency of PSII, Photo-oxidizable PSI & photosynthetic gas exchange, chlorophylls, & carotenoids.	5
TiO_2	0 & 5 mg/L	*Cicer arietinum L.*	Foliar	Cold	Reduced oxidative stress, electrolyte leakage index, & increased productivity.	6
TiO_2	0, 2 & 5 ppm	*Glycyrrhiza glabra* L.	MS medium	Cold	Decreased MDA & H_2O_2 contents.	7
Mn	0, 0.1, 0.5 & 1.0 mg/L	*Capsicum annuum* L.	Seed	Salinity	Enhanced root elongation & germination.	8
Se	0, 10 & 20 mg/L	*Fragariax ananassa* Duch.	Foliar	Salinity	Improved growth, yield, quality, & fruit nutritional value. Reduced LP & H_2O_2. Accumulated IAA, & ABA.	9
MWCNTs	0, 10, 20, 40 & 60 mg/L	*Brassica oleracea* L. var. Italica	Hydroponic	Salinity	Improved photosynthesis, water uptake, rigidity & permeability of roots & plasma membrane.	10

MWCNTs	20 mg/L	*Brassica napus* L.	MS medium	Salinity	Reduced ROS, thiobarbituric acid reactive substance production, & Na^+/K^+ ratio.	11
MWCNTs-COOH	0, 25, 50 & 100 mg/L	*Ocimum basilicum L.*	Hydroponic	Salinity	Increased chlorophyll, carotenoids, growth, essential oil content &, induced enzymatic & non-enzymatic antioxidants.	12
CeO	0 & 500 mg/L	*Gossypium hirsutum* L.	Seed	Salinity	Decreased ROS in roots, & increased root growth.	13
ZnO & Si	0, 100 & 150 (ZnO) & 0, 150 & 300 (Si)	*Mangifera indica* L. Ewais	Foliar	Salinity	Increased growth, nutrient uptake, carbon assimilation, & reduced malformation of flowers.	14
FeO	0, 30, 60, & 90 ppm	*Dracocephalum moldavica* L.	Foliar	Salinity	Increased leaf area, enzyme activities, & antioxidant defense.	15
ZnO	10 mg/L	*Abelmoschus esculentus* L. Moench cv. Hasawi	Foliar	Salinity	Increased photosynthetic pigment &, CAT & SOD activity. Decreased proline & total soluble sugars.	16
Graphene & CNTs	0, 50, 100, 200, 500, 1000 (graphene) & 0, 50, 200 µg/ml (CNTs)	*Gossypium hirsutum* & *Catharanthus roseus*	Seed	Salinity	In vinca plants, increased flower & leaf quantity, & increased fiber biomass in cotton.	17
Cit-Ag	1mM	*Zea mays* L.	Foliar	Salinity	Improved photosynthesis, dry weight, total osmolytes, SOD & POD.	18
Ca	0, 2.5, 5, 10, 15, 20 mM	*Solanum lycopersicon* L.	Irrigation	Salinity	Improved survival, anabolic, growth, enzymatic antioxidant activities & osmolytes accumulation.	19
ZnO	0, 15, & 30 mg/L	*Fragaria x ananassa* Duch. & Camarosa	In-vitro	Salinity	Increased CAT, POD, & proline content. Decreased build-up of toxic ions Na^+ & Cl^- as well as Na^+/K^+ ratio.	20

ZnO proline doped	0, 50, & 100 mg/L	*Coriandrum sativum*	In-vitro	Salinity	Decreased antioxidant, phytochemical activities, SOD & POD. Increased plant weight.	21
ZnOBt	0, 50, & 100 mg/L	*Coriandrum sativum*	In-vitro	Salinity	Increased root & shoot length, plant weight. Decreased SOD & POD.	22
Si	20 mg/L	Rice (N-22 and Super-Bas)	Foliar	Salinity	Stimulated growth, chlorophyll, carotenoids, total soluble protein, & POD and HKT genes were upregulated.	23
Si	75 mg/kg	*Zea mays* L.	Soil	Salinity	Increased dry weight, chlorophyll content, transpiration, stomatal conductance, internal CO_2 concentration &, availability of nutrients.	24
CeO_2 & CeO_2-SA	0, 100 µM (SA), 50 mg/L (CeO_2), 25 mg/L + 50 µM (CeO_2-SA), 50 mg/L + 100 µM (CeO_2-SA)	*Mentha spicata* L.	Foliar	Salinity	Improved protein, carbohydrate, phenolics, total antioxidant capacity, flavonoids, & essential oil percentage. Decreased proline, GPX, H_2O_2, APX &, SOD.	25
Se-CS	0, 10 & 20 mg/L	*Momordica charantia*	Seed	Salinity	Increased photosynthesis, antioxidant enzymatic activity & nutrient homeostasis.	26
GO & GO-Pro	0, 50, 100 mg/L	*Vitis vinifera* L. cv Vitaceae	Foliar	Salinity	Reduced H_2O_2, MDA, & electrolyte leakage, & increased proline.	27
SiO_2	0, 10, 50 & 100 mg/L	*Crataegus* sp.	Soil	Drought	Increased plant biomass, xylem water potential & malondialdehyde.	28
SWCNTs	0, 50, 100, 200, 400 & 800 µg/mL	*Hyoscyamus niger*	seed	Drought	Increased water uptake, germination, & seedling vigor index. Decreased H_2O_2, MDA & electrolyte leakage.	29

Graphene & CNTs	0, 50 200 μg/ml (graphene & CNTs)	*Gossypium hirsutum* & *Catharanthus roseus*	Seed	Drought	Increased plant survival & no symptoms of drought stress.	17
(GSNO-CS-NP)	100 μM	Sugarcane	Foliar	Drought	Increased drought tolerance, root & shoot ratio.	30
TiO_2	0, 500, 1000 & 2000 mg/kg	*Triticum aestivum*	Soil/foliar	Drought	Improved seedling dry weight, RWC, CAT, APX, proline, total chlorophyll, carotenoids, stomatal conductance, & transpiration.	31
Chitosan (CSNP)	1%	*Catharanthus roseus*	Foliar	Drought	Promoted proline accumulation, CAT, APX, & reduced H_2O_2 & MDA.	32
Fe_2O_3	0, 5, 10, 20, 30 & 40 μM	*Vitis vinifera* L.	Root	Drought	Improved AsA-, GSH-, & CAT.	33
ZnO	0, 75, 100, 125 &150 mg/L	*Curcumis melo* L.	Hydroponic	Drought	Improved SOD, POD, CAT, APX, DREB2D, & DREB3, soluble sugar, protein, & chlorophyll.	34
SiO_2	50 mg/L	*Fragaria* X *ananassa* Duch.	Foliar	Drought	Increased osmolytes proline, total soluble sugar, chlorophylls, & carotenoids. Up regulated some responsive genes which modified ABA & phenolic compounds.	35
Ag	0, 40, 80 & 120 ppm	*Crocus sativus* L.	Root	Flood	Increased leaves dry weight, root number & length.	36
Al_2O_3	0, 5, 50, 500 ppm	*Glycine max* L.	Solution	Flood	Enhanced seedling growth. Reduced cytotoxic byproducts of glycolysis.	37
Ag	5 ppm (2, 15 & 50-80 nm)	*Glycine max* L. cv. Enrei	Solution	Flood	Increased root size & amino acid synthesis related proteins.	38
Ag	5 ppm	*Glycine max* L.	Solution	Flood	Enhanced growth, length, & weight. Increased accumulation of calnexin/ calreticulin & glycoproteins	39

SiO_2	250 mg/L	*Poncirus trifoliata* L., *Poncirus trifoliata* L. & Rich 16-6	Root/Foliar	Flood	Increase biomass, photosynthesis, growth, polyamine metabolism & reduced ROS.	40
Si	10 µM	*Triticum aestivum*	Hydroponic	UV-B	Enhanced antioxidants, lowered ROS & protected photosynthesis.	41
TiO_2	0, 25 & 50 mg/L	*Crocus sativus* L.	Foliar	UV-B	Increased yield & nutritional value.	42
Ag	0, 50 & 100 mg/L	*Thymus vulgaris* L.	Foliar	UV-B	Improved plant growth yield.	43
ZnO	0, 25, 50, 75 & 100 mg/kg (soil), 0, 25, 50, 75 & 100 mg/L (foliar)	*Triticum aestivum*	Soil/foliar	Metal	Increased growth, photosynthesis, grain yield, Zn content, & reduced electrolyte leakage & Cd toxicity.	44
Fe	0, 5, 10, 15 & 20 mg/kg (soil), 0, 5, 10, 15 & 20 ppm (foliar)	*Triticum aestivum*	Foliar & Soil	Metal	Reduced Cd toxic effects & enhanced Fe biofortification. Improved morphological parameters, photosynthesis, & growth.	45
SiO_2	1%, 3%, 5%, 10%, 15% & 20%	*Cicer arietinum*	Germination paper	Metal	Enhanced antioxidant genes & reduced cytotoxicity of LP & provided tolerance against Al-toxicity.	46
TiO_2	0, 100 & 250 mg/L	*Zea mays* L.	Foliar	Metal	Decreased Cd content in plants & increased SOD, GST.	47
ZnO and Biochar	0, 50, 75 & 100 mg/L (ZnO), 1.0% w/w (biochar)	*Zea mays* L.	Foliar	Metal	Increased biomass, Zn content, enzymatic activity, and decreased oxidative stress & Cd accumulation.	48

ZnO	25 mg/L	*Oryza sativa* L.	Hydroponic	Metal	Decreased Cd accumulation. Improved growth & antioxidant enzymatic activity.	49
Si+TM	10 mL suspension at 2% & 3%	*Solanum lycopersicum* L.	Soil	Metal	Decreased Cd bioavailability & translocation. Increased Cd tolerance, plant growth & antioxidant enzymatic activity.	50
CeO_2	0, 200, 400 &600 mg/L	*Abelmoschus esculentus* L. Moench	Foliar	Metal	Increased chlorophyll & carotenoids. Modulation in stress enzymatic activity of APX, GPx, & SOD.	51
Put-CQD	25 & 50 mg/L	*Vitis vinifera* cv. Sultana	Foliar	Metal	Reduced Cd content in plant tissues. Increased fresh & dry weight in plant tissue.	52
ZnO	10 ppm	*Zea mays* L. vr. CZP 312001	*in-silico*	Metal	Improved Zn, Cu, Na, Fe, K, Ca, & Mg uptake, biomass, chlorophyll *a, b* & carotenoids protein interactors regulation. Reduced Cd in shoots.	53
SiO_2	400 mg/L	*Brassica napus* L.	Seed	Metal	Improved photosynthesis & plant immunity. Reduced Cr accumulation, MDA, H_2O_2, & O_2-.	54
α-Fe_2O_3	50 mg/kg	*Cucumis melo* L.	Seedling	Metal	Decreased Cd toxicity, SOD, CAT and downregulated the expression of DEGs. Increased photosystem I & activated auxin-responsive genes.	55
Si & TiO_2	0, 5, 10, 20 & 30 mg/L (Si & TiO_2)	*Oryza sativa* L.	Foliar	Metal	Enhanced growth & mitigated the Cd translocation.	56
S	0 & 300 mg/L	*Brassica napus* L.	MS medium	Metal	Alleviated Hg toxicity in *Brassica napus* L., increased dry weight, and the uptake of macro- and micro-nutrients.	57
ZnO	0, 25, 50, 100, 150 & 200 mg/L (50 seeds)	*Vigna mungo* L. Hepper	Seed priming	Metalloid	Increased seed germination & plant growth. Decreased ROS build up, & As translocation to root & shoot.	58
ZnO	20% w/t	*Coffea arabica*	Foliar	Nutrient	Increased dry & fresh weight,	59

		L.		deficient	photosynthetic rate & Zn content.	
ZnO	0, 10, 20, 50, 100, 200 & 1000 mg/kg	*Triticum aestivum* L.	Soil	Nutrient deficient	Increased Zn content ingrain, grain yield & biomass.	[60]
ZVI, Fe_3O_4, & Fe_2O_3	0, 50, 250 & 500 mg/L (Fe-based)	*Oryza sativa L.*	Kimura solution	Nutrient deficient	Increased Fe & chlorophyll & reduced stress-related phytohormones.	[61]
Zn & Mg-doped hydroxypatite	0, 50%, 75% & 100%	*Triticum aestivum* L.	Soil	Nutrient deficient	Served as a multi-nutrient complex that includes N, Ca, P, Mg, & Zn. Mitigated ammonia emissions, enhanced soil dehydrogenase, urease enzyme levels, & height.	[62]
Cu	0, 100 & 1000 mg/L	*Hordeum vulgare* L.	Foliar	Nutrient deficient	Improved pigment, biomass, GSH content, & stress tolerance.	[63]
NZVI	0, 1, 2, 5 & 10 g/kg	-	Soil	Problem soils/ antibiotics	Degradation of TC in soil.	[64]
Chitosan with N-Acetyl cysteine	0.5 mg/ml + 0.05%	*Triticum durum*	Foliar	Ozone	Increased leaf antioxidant & weight of 1000 seeds.	[65]
Ag	25 mg/L & 50 mg/L	*Triticum aestivum* L.	Foliar	Ozone	Enhanced ozone tolerance, & increased yield, & weight.	[66]
CeO_2	0, 200, 400, 600 & 1000 mg/kg	Wheat	Soil	Metal & alkalinity	Decreased Cd availability in soil, & accumulation in all plant organs. Increased dry weight, grain yield & plant physiology.	[67]
Si	0, 2.5 & 5.0 mmol/L (20, 30 &40 days	*Phaseolus vulgaris* L., cv. Bronco	Foliar	Metal & salinity	Saline soil contaminated with Cd, Pb, & Ni was mitigated by enhancing enzymatic & non-enzymatic antioxidants. Increased	[68]

	after sowing				growth yield.	
Fe	0, 25, 50 & 100 mg/kg	Wheat	Soil	Metal & Drought	Increased growth & photosynthesis in plant & Fe concentrations in grain. Decreased Cd content, ROS, & drought stress.	69
ZnO	0, 50 & 200 mg/L	*Oryza sativa* L.	Hydroponic & Foliar	High temp. & osmotic	Increased ROS & H_2O_2. Up-regulated defense-related genes, OsNAC4, OsPR10, OsKSL4, & OsPR1b.	70
CaP	30 mg/L (foliar),	*Persea americana* Mill cv. Hass	Foliar & Soil	High temp. & drought	Reduced water stress & increased resistance to heat.	71
Ag	40 mg/L	*Zea mays* L.	Seed priming	Cold	Increased germination speed, seedling vigor, shoot & root length &, dry weight.	72
				Salinity	Increased germination rate & seed vigor, root length, & dry weight.	
				Drought	Increased germination rate, seedling vigor, root length &, dry weight.	
				Cold & Salinity	Increased seedling vigor, root length, & dry weight.	
				Salinity & drought	Increased germination percentage, seedling vigor, & root length.	
				Drought & cold	Increased germination rate, seedling vigor, root length &, dry weight.	

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Table 2. Summary of different nanomaterials for mitigating biotic stress.

NM	Conc.	Apl.	Crop/s	Biotic stress	Effect/s	Ref.
Nanocapsule with loads Eucalyptus extract	0, 10, 15, 25, 35 & 50 mg/ml	Fumigation	-	Insects	Mitigates damage caused by *Myzus persicae*.	1
CNAP-HMS-PDAAM	0, 30.0, 34.5, 39.0 & 69.0 g a.i./ha (field) 0, 25, 50, 100 & 200 mg/L (petri dish)	Foliar	*Oryza sativa* L.	Insects	Efficient against *Cnaphalocrocis medinalis* & *Chilo suppressalis*, showed good biosafety.	2
THI@HMS @P(NIPAM-MAA)	0, 4, 8, 16 & 32mg/L	Foliar	*Oryza sativa* L.	Insects	Improved efficacy against *Nilaparvata lugens*. Strong adhesion to leaves, & protection against UV-degradation.	3
DNF@MIL-101@CMCS	3 g a.i./kg	Pesticidal application	*Oryza sativa* L.	Insects	Maintain insecticidal effect for longer period & improved plant growth.	4
TMX-loaded UIO-66-NH2/SL	treatment & seeds mixed at mass ratio 1/200	Seed	*Oryza sativa* L.	Insects	Protect against planthopper.	5
***sh*RNA on CeO_2 Dextran-DEAE**	50, 100, 250 ng/µl	Orally	-	Insects	Increased mortality of *Euschistus heros* at ratio 0.7:1	6

Abam-PLA-Tannin-NS and Azox-PLA-Tannin-NS	0.78125, 1.625, 3.125, 6.25, 12.5, 25 & 50 ppm (Abam-PLA-Tanin-NS for aphids) 0.1, 0.5, 1, 5, 10 & 20 ppm (Azox-PLA-Tannin-NS for *Fusarium*)	Foliar	*Brassica oleracea* L.	Insects & fungus	Improved adhesion to foliage, photostability, continuous release. Abam-PLA-Tannin-NS mitigation to *Myzus persicae* L. & Azox-PLA-Tannin-NS mitigation against *Fusarium*.	7
GNPs	0.1% w/v	Foliar	*Curcuma longa*	Fungal	Reduced rot incidence from *Pythium aphanidermatum*. Increased activity of defense enzymes of PO, PPO, & PI.	8
SiO_2	0, 5, 10 &15 kg/ha	Soil	*Zea mays* L.	Fungal	Increase phenolic content & activate defense enzymes.	9
CeO_2	0, 50 & 250 mg/L	Foliar & Soil	*Solanum lycopersicum*	Fungal	In foliar it decreased sugar content & increased fruit dry weight and Ca, P, & S. In soil, increased fruit K content, dry weight, & lycopene.	10
Chitosan	0.1% (w/v)	Foliar	*Solanum lycopersicum* L.	Fungal	Decreased wilt disease symptoms. Increased yield & protection against *Fusarium oxysporum* f.sp. *lycopersici*.	11
Chitosan	2m of 0, 100, 500, 1000 & 5000 ppm	Solution	*Triticum aestivum* L.	Fungal	Inhibited radial mycelial growth. Reduced colonies of *Fusarium graminearum*.	12
Chitosan	5 ml/plant	Spray	*Eleusine coracana* Gaertn	Fungal	Inhibited growth of *Pyricularia grisea*, delayed symptoms & induced ROS.	13

H-CSNPs	$Harpin_{pss}$ with CSNPs (90% EE)	Foliar	*Solanum lycopersicum* L.	Fungal	Improved permeability, stability, & bioavailability of $Harpin_{pss}$. Increased defense responses.	14
AZOX@MSNs-PDA-Cu	0, 111, 222 & 333 mg/L AZOX concentration	Foliar & plate method	*Cucumis sativus*	Fungal	Improved fungicidal activity against *Pyricularia oryzae* & P. *xanthii*.	15
Chitosan	1 mg/mL	Seed pre-soaked, soil & foliar	*Oryza sativa* L. var. Jyothi	Fungal	Efficacy against *Rhizoctonia solani*. Increased defense enzyme activity.	16
PYR-HMS-HPC	0, 0.02, 0.04, 0.08, 0.16 &0.32 mg/L	Hyphal growth rate method	-	Fungal	Fungicidal activity against *Magnaporthe oryzae* & less genotoxicity of pyraclostrobin.	17
Pro@MSN-Pec	45% (2g/L for leaves & roots) & (0.03125, 0.0625, 0.125, 0.25, 0.5 &1 mg/L in petri dish)	Leaves and roots (for extraction of Pro residues) & petri dish (against fungus)	*Oryza sativa* L.	Fungal	Improved antifungal activity against *Magnaporthe oryzae*.	18
Mycogenic ZnO	261.136, 130.568, 65.284, 32.642, 16.321, 8.1605, 4.08, 2.04, 1.02, 0.51 µg/L (3 applications)	Petri dish & Foliar	*Solanum tuberosum* L.	Fungal	Fungicidal effect against *Alternaria Solani* early blight & increased tuber production.	19
Chitosan	0.001% & 0.1% (petri dish) &0.001% (foliar spray)	Petri dish & Foliar	*Capsicum annuum* L.	Fungal	Improved immunity against *Alternaria* leaf spot disease. Callose deposition was produced & reduced cell death.	20

CeO_2	0, 50, 75& 100 mg/L (two applications)	Foliar	*Triticum aestivum L.*	Fungal	Effective against *Ustilago tritici.* Enhanced grain production, height, spike-length, & straw yield.	21
Ag	0, 0.01%, 0.02%, 0.03%, 0.04 &0.05%	Foliar	*Lycopersicum esculentum*	Fungal	Effective against *Botrytis cinera.*	22
Ag	0 &300 ppm	Dipped in solution	*Garcinia mangostana* L.	Fungal	Decrease disease index of fruit rot caused by *Lasiodiplodia theobromae*. Enhanced plant defense enzymes PAL, POD, CHI & GLU.	23
Ag Chitosan	1.6 mL	Seed	*Tricum vulgare*	Fungal	Antifungal properties against *Fusarium oxysporum*, *Aspergillius niger*, *Aspergillius versicolor*, & *Aspergillius brasiliensis,* increased chlorophyll content.	24
PYR@OxbCD	250 µg/mL	in-vitro & foliar	*Oryza sativa* L.	Fungal	Fungicidal activity against *Rhizoctonia solani*. Enhanced POD & CAT, & defense genes.	25
ZnO	0, 50 & 200 mg/L in Yoshida solution or sprayed	Hydroponic & sprayed	*Oryza sativa* L.	Fungal	Reduced *Magnaporthe oryzae* & increased ROS accumulation acting against the fungal stress.	26
Chitosan-magnesium	0, 25, 50 & 100 µg/mL	Agar well diffusion method	*Oryza sativa* L.	Bacteria & fungal	Antimicrobial activity against bacteria *Acidovorax oryzae* & fungal *Rhizoctonia solani*.	27

Ag	0, 10, 20, 30, 40, 50, 60, 70 & 80 µg/mL	In-vitro	-	Bacteria	Antimicrobial effects against *Bacillus cereus* & *Pseudomonas syringae* pv. *syringae* & low toxicity against murine macrophages RAW2647.	28
Chitosan	0, 100 & 200 µg/mL	Foliar/soil	Potato and Tomato	Bacteria	Reduced disease severity in both plants against *Ralstonia solanacearum*.	29
Chitosan	0, 10, 50, 100, 150, 200, 250 &500 mL/100kg seeds	Seed	*Solanum lycopersicum* L.	Bacteria	Increased PAL, POX, PPO, CAT & GLU. Help in the defense against bacterial wilt disease (*Ralstonia solanacearum*).	30
Si+TM	10 mL suspension at 2% & 3%	Root/Soil	*Solanum lycopersicum* L.	Bacteria	Reduced bacterial wilt disease & disrupted cellular morphology of *Ralstonia solanacearum*.	31
ZnO (pristine and sulfidized	0, 100 &500 mg/Kg	Soil	*Glycine* max, Zhonghuang No. 13	Bacteria	Reduced bacterial alpha diversity in roots & nodules.	32
Ch@BSNP	0, 5%, 10%, 15% & 20% of Ch@BSNP (60 µg/mL)	Foliar	*Solanum lycopersicum* L.	Bacteria	Antibacterial effect against leaf spot disease caused by *Xanthomonas campetris* pv. *Vesicatoria*. Decrease anthocyanin, proline, flavonoids, lipid peroxidation, guaiacol peroxidase, ascorbate peroxidase, polyphenol oxidase, & phenylalanine ammonia-lyase.	33

AuNR (FOPPR immunosensor)	-	crude sap extraction	*Phalaenopsis* sp.	Virus	Helps in the rapid quantitative analysis of viral infection diagnosis by recognizing *Cymbidium mosaic* & *Odontoglossum ringspot*.	[34]
NBCs	0, 150 & 200 µM	Foliar	*Vicia faba* L.	Virus	Reduced severity symptoms of *Bean yellow mosaic virus*. Increased growth, photosynthetic pigment, enzymatic, non-enzymatic antioxidants, soluble protein, membrane stability index, & water content.	[35]
Fe_3O_4	100 µg/mL daily for 12 days	Foliar	*Nicotiana benthamiana*	Virus	Increased dry & fresh weight. Activated plant antioxidants, & SA responsive PR related gene. Showed plant resistance against *Tobacco mosaic virus*.	[36]
AuNP assay	1 ng/µL to 1 ag/µL	-	*Capsicum annuum* L & *Solanum lycopersicum*	Virus	Better screening detection than PCR test for *Begomovirus*.	[37]
ZnO	0 & 200 mM	Foliar	*Capsicum annuum* L	Virus	Decrease symptoms by *Pepper huasteco yellow vein virus*. ZnONPs restricted the mobility of the virus, by increasing POD and SOD.	[38]

BQX@PP@S NPs	0 & 500 mg/L	Foliar	*Nicotiana glutinosa, N. benthamiana,* & *Nicotiana tabacum* cv. K326	Virus	Antiviral properties against *Tobacco mosaic virus*. Activated plant defense response & upregulated expression of SA & ABA genes. Increased fresh & dry weight.	39
Ag	0, 0.25, 0.50 & 1.0 mM (15 mL solution)	Root/Soil	*Solanum lycopersicum* L.	Nematodes	Improved plant growth, reduced infection, number of galls, egg masses & *Meloidogyne incognita* effects.	40
AVM-CS/γ-PGA	0, 0.0625, 0.125, 0.25, 0.5 & 1 ppm	*in-vitro*	-	Nematodes	Nematocidal properties against *Pine wood nematode* by increasing mortality by 98.6% in 24h.	41
Ag	0, 0.15, 0.3, 0.6, 1.2 & 2.4 ml/L, v/v (*in-vitro*) & 0, 1, 2 & 3 ml/kg of soil (*in-vivo*)	*In-vitro* & Soil	*Vicia faba* L.	Nematodes	Inhibited egg hatching of *Meloidogyne javanica in-vitro. In-vivo* reduced root galling & enhanced plant growth.	42
Et-AgNPs	0, 100, 250, 500 &1000 (ng/mL *in-vitro*) & (ng/mL in 5 mL root)	*in-vitro* & root	*Solanum lycopersicum* L.	Nematodes	*In-vitro* showed nematocidal properties, inhibition of egg hatching & mortality to juvenile *Meloidogyne incognita*.	43
Ag	0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 80 & 100 ppm	embryogenesis study	*Solanum nigrum* L.	Nematodes	Nematocidal properties with applications 20 & 40 ppm in 24h & increase mortality against *Meloidogyne incognita*.	44

Ag	0, 25, 50 &100 ppm	Root/Soil	*Trachyspermum ammi* L.	Nematodes	Mitigate stress induced by *Meloidogyne incognita*. Enhanced plant growth, & defense enzymes peroxidase, CAT, SOD, APX). Accumulated lignin in roots.	45
Ag	0, 25, 50 & 100 µg/mL	*in-vitro*	-	Nematodes	Biosynthesized Ag NPs showed a nematocidal properties after 48h by reducing egg hatching, larva movement & increase mortality of *Melioidogyne incognita*.	46
Sg-ZnO Nrs	0, 100, 200, 300, 400 & 500 µg/mL	*in-vitro* &seed treatment	*Solanum lycopersicum* L.	Nematodes	Increased seed germination & growth. Showed nematocidal properties against juvenile stage of *Meloidogyne incognita*.	47
THI@PAMAM@MSN	0, 50, 100 & 200 µg/mL (based on THI content in µg/g)	Spray application with drone	*P. tabulaeformis*	Nematodes	pH responsive release for 14d having nematocidal properties against *Bursaphelenchus xylophilus*.	48
AVB1a NCs	1.0 mg a.i./plant diluted with 200 mL of DI water	Root	*Solanum lycopersicum* L.	Nematodes	Efficacy against *Meloidogyne incognita*. Improved permeability in root, soil mobility & shelf life. Reduced harm in other organisms.	49
ZnO	0 & 7.5 mg/L	Solution application	-	Nematodes	Decrease pathogen (*Klebsiella pneumoniae*) & their biofilm formation in *Caenorhabditis elegans*.	50

SiO2	5 mL of 0, 400, 2000 & 4000 mg/L (seeds) & 10 mL of 0, 400, 2000 & 4000 mg/L daily for 16 days (soil)	Seed treated & soil	*Zea mays* L. *Phaseolus vulgaris* L., *Hyssopus officinalis*L. &*Tarazacum officinale* F.H. Wigg	Weeds	Increase germination, yield, photosynthetic pigment, total protein, & amino acid, except in *Hyssopus officinalis*. Decrease total protein, total carbohydrates, & proline content in weeds.	51
herbicide-loaded pectin nanoparticles	200 mL solution &0.05 g/L concentration	Foliar application to weed	PBW 343, *Triticum. aestivum*	Weeds	Efficacy getting rid of weed *(Chenopodium album*) with less herbicide quantity.	52
Salt@MSN-TA	10 mL at concentration 0.6 kg/ha (petri dish) & 2.5 kg/ha (soil)	petri dish & soil	*Cucumis sativus* L. and *Triticum aestivum* L.	Weeds	Delayed soil leaching, continued with herbicidal activity against targeted plant (*Cucumis sativus* L.).	53
LCHP	0 & 210 mg in aqueous solution	Foliar	-	Weeds	Improved adhesion & effectiveness against weeds (Bermuda and Cogon). Light responsive controlled delivery of herbicide, & reduction of environment contamination.	54
MLH-MPP/CMC	$5.0x10^{-6}$ M, $1.0x10^{-5}$ M & $8.0x10^{-4}$ M percentage loading of MPP (% w/w)	N/A	-	Weeds	Improved prolongation & control of the release system of MPP.	55
Tribenuron-Metlhyl-Microemulsion	15 g a.i./ha	Spray	*Triticum aestivum* L.	Weeds	Herbicidal activity at low concentrations towards wheat weed (*Convolvulus arvensis*).	56

2,4-D@HTlcs nanosheets	75, 150 & 300 mg/L of 2,4-D concentration	Suspension	-	Weeds	Reduction of volatilization, delayed leaching through soil, & efficient against *Amaranthus retroflexus* weed.	57
MOF@DIS-NH2 and MOF@DIS-*O*- acetil	10, 30, 100, 300 &1000 µM	Water dispersion	-	Weeds	Phytotoxic against three types of weeds *(Lolium rigidum Gaudin, Echinochloa crus-galli* L. &*, Amaranthus viridis* L.).	58
MCRH	0.5 mg in 10 mL of water	Spray	-	Weeds	Regulates release by magnetic field, same herbicidal as glyphosate against *tifdwarf bermudagrass*.	59
ZNP-ATZ	0, 25 and 2000 g/ha	Soil application	*Zea mays* L.	Weeds	Reduced toxicity exposure in corn plants and showed toxicity against *Brassica juncea*).	60

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