A Review on the Potential of Plant Extracts in Progressive Agriculture

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Abstract

Weeds, fungus, and insect pests have caused a significant decline in productivity in Indian agriculture since its inception. Weeds may reduce agricultural production by 5-50%. Insect pests are a major threat to farmers as they consume crops, stored grains, and spread illnesses to animals. Fungi may damage agricultural and horticultural crops, resulting in economic losses and health risks for consumers owing to their mycotoxin production. Chemical monitoring of bio agents has led to weed, fungal, and insect resistance, increased costs, and residual toxicity levels, rendering fruitful areas barren and hazardous. The best solution is to use indigenous traditional methods of control used by farmers, such as plants that were once common all over the world but have almost disappeared in developed countries due to the introduction and use of modern synthetic chemicals. These plants are now only found in a few regions of developing countries. Plant extracts include bioactive components that can control crop-destroying chemicals, as reported by several sources. This report summarises the findings of employing plant extracts to monitor plant bioagents. Plant extracts are cost-effective, ecologically benign, and widely accessible, making them ideal for sustainable agricultural production.

Keywords: Pests, Weeds, Chemicals, Plant Extracts, Diseases, and Sustainable Agriculture.

Introduction

The overuse and reliance on chemicals in agriculture has led to a number of negative outcomes for humans and wildlife, including weed, fungal, and pest resistance, pest resurgence, which has caused minor agents to attain major status, the elimination of natural enemies, higher levels of residual toxicity in soil, and environmental contamination of air, soil, and water. A major obstacle to the development of many crops is weeds. Due to its affordability and convenience of use compared to manual weeding, chemical weed management has become more and more popular among farmers in recent years. Many environmental issues, such as hazards to human health and the development of weed resistance, have been brought about by the widespread use of synthetic herbicides (Jabran et al., 2010).

Pests and illnesses of various kinds harm almost all crops worldwide, with fungal pathogenic diseases accounting for the majority of these cases. Additionally susceptible to grains that lose dry matter and grain production, which lowers the quality of feed and seed supplied by important fungal

species such Fusarium, Alternaria sp., Aspergillus, and Penicillium (Magan and Aldred, 2007). The primary measure for managing fungal growth is the use of post-harvest fungicides that do not compromise the quality of the product (Amiri et al., 2008).

Since some antimicrobial chemicals are not biodegradable and build up in soil, plants, and water, harming living things, they have been used for decades to control plant diseases. This has led to the development of resistant pathogen populations as a result of increased concentrations in food products.

Because they devour crops and stored grains and act as a vector for illnesses that affect animals, insect pests are considered farmers' deadliest foes. These pests are controlled using chemical pesticides, but because of their extensive use, pests have developed a resistance to the pesticides and their residual toxicity has increased, turning fruitful fields into poisonous and barren settings. Only 0.1 percent of synthetic chemical pesticides are effective against the intended pests; the other 99.9% are discharged into the environment and pose dangers to human health and the environment.

The macro and microflora and fauna are negatively impacted by the poisoning of soil and water supplies by synthetic chemical pesticides.

It is therefore crucial to search for substitute control strategies that will cut down on the use of artificial chemicals. Using botanicals, biopesticides, and biocontrol agents to manage chemical resistance in weeds, fungus, and insects is becoming more popular as environmental protection and the demand for food free of chemical residues expand worldwide. These compounds do not adversely affect plant development characteristics and are effective against weeds, fungus, and insects that have developed chemical resistance.

According to Rosenthal et al. (1991), plants generate a variety of secondary plant metabolites that are poisonous and serve as antimicrobial pathogens while having little effect on plant growth and development. (Schafer and associates, 2009).

One practical way to reduce post-harvest losses is to investigate plant-based pesticides. This is because plant-based pesticides may be used sustainably in the environment and are a rich source of natural chemicals with a variety of fungicidal and other qualities as well as minimal side effects. It has been shown that more than 2500 plant species from 235 families possess the qualities needed to create the ideal botanical pesticide.

About 350 insecticidal compounds, more than 800 insect feeding deterrents, and a significant number of insect development inhibitors and regulators have been produced by different plant species. Many plant components, including as leaves, stems, seeds, roots, bulbs, rhizomes, unripe fruits, and owers heads, are used to make botanicals. Because of this, a variety of natural plant chemicals have been tested for use in agriculture. It is important to remember that natural chemicals need to be suitable for the agrochemical industry, have optimal target pathogens and potential target

sites, and be sensitive at very low doses. All of these requirements can be met by conducting appropriate dose response studies.

Due to the extended use of chemical pesticides, agriculture has been struggling since the early 1970s with the establishment of pathogen resistance to disease control agents. This has led to public demand for safer pesticides that have less of an impact on the environment. It is thus a good idea to analyse natural products and extracts as a fresh source of approach for the identification of novel compounds that chemists have not yet developed (Wedge and Smith, 2006).

In this instance, a newly researched method for controlling plant diseases that replaces chemical fungicides by eliminating these artificial compounds or, at the absolute least, controlling their application in combination with natural fungicide substances is called integrated pest management.

The fundamental idea is biological control to improve soil and health. Farmers have certainly profited from the use of chemicals, but over time, the environment has been seriously threatened by their ongoing use in agriculture. A new dimension is provided by the development of excellent sources of biologically active natural products through the incorporation of more environmentally friendly and sustainable crop management practices, among which botanical plant extracts. The Green Revolution's vices are being corrected by growing consumer demand for organic food and policy support for sustainable agriculture. Consequently, botanicals have the power to promote safe agriculture and bring in a new age of agricultural sustainability. It need additional awareness campaigns in order to market.

Plant Extracts:

A solution is created by digesting plant components with a solvent and condensing them by evaporation, distillation, or other processes. Plant extracts, including garlic (Allium sativum), have been studied for antibacterial properties against bacteria, fungi, and viruses (Cavallito and Bailey, 1994; Adetumbi et al., 1986). (weber et al., 1992). Ginger (Zingiber officinale) has been demonstrated to have analgesic, sedative, cardiotonic, and antibacterial qualities. It can also kill E. coli and B. cereus bacteria (Hibert, 2006; Wood, 1988). Kim et al. (2005). Onion (Allium cepa) has antibacterial properties against B. subtilis, Salmonella sp., and E. coli, as well as molten aflatoxin (Winston, 2008; Sharma et al., 1979).

To address the hazards associated with pesticide usage, researchers are focusing on finding non-toxic, ecologically acceptable alternatives for people and animals that are swiftly biodegradable.

Plant Extracts in Crop Protection:

Botanical goods are plant materials with recognised pesticidal, medicinal, or therapeutic properties. According to Prakash and Rao (1996), phytopesticides may range from fresh herbs to bioactive isolates that effectively combat pests and diseases. Natural pesticides may be made in several forms, including small bags, dried products, liquid extracts, powders, and cakes. Botanicals have been

employed to treat agricultural pests for over 2000 years in ancient China, Egypt, Greece, and India (Isman 2006). Traditional botanical pest management is still commonly used among subsistence and transitional farmers for safety and storage purposes (Belmain and Stevenson 2001; Gerken et al. 2001). Botanicals are widely utilised in Zimbabwe and Uganda, with up to 100% of people using them (Makaza and Mabhegedhe 2016; Nyirenda et al. 2011).

Farmers' methods for preparing various indigenous herbs

Neem (Azadirachta indica) Leaf Extract:

Materials needed: Neem leaves (80kg/ha).

Fresh neem leaves were picked and steeped overnight in water. The next day, the wet leaves were crushed and the extract was filtered. The filtered extract was diluted to 2.53 L in 50 L water and sprayed.

Neem's insecticidal abilities are assumed to be due to the presence of limonoids. Although azadirachtin A is believed to be the most effective ingredient in neem insecticides, other limonoids may also play a role (Boursier et al. 2011; Isman et al. 1990). Lynn (2010), Nathan et al. (2005), and Feng and Isman (1995) suggest that azadirachtin A resistance may be prevented.

Commercial neem extracts are often used to monitor a broad range of insects and mites. Research has shown that commercial neem-based treatments have strong insecticidal and acaricidal capabilities (Morgan 2004). Homemade aqueous extracts of neem plant material (leaves, seeds, seed cake, and unformulated oil) effectively control blattodean pests (Ibrahim and Demisse 2013), hemipteran pests (Aziz et al. 2013; Degri et al. 2013; Gupta and Pathak 2009), and lepidopteran pests (Abate 2011; Attia et al. 2011; Tables 1 and 2). Neem aqueous extracts was efficient in seven out of eight studies against lepidopteran pests. Foliar or soil treatment of neem aqueous extracts for insect pest management beat negative controls in 15 of 18 instances. Additionally, yield was raised in all 9 experiments with yield measurements. In ten of fifteen instances, neem aqueous extracts were comparable to synthetic pesticides, whereas in five, they were inferior. Patil and Nandihalli (2009) demonstrated the effectiveness of neem aqueous extracts and oil emulsions against mite pests in field applications. The preparations reduced mite population but did not affect yield.

Ground neem plant material has been shown to effectively monitor coleopteran pests in storage experiments (Ahmad et al. 2015; Boeke et al. 2004b; Ileke and Oni 2011; Ilesanmi and Gungula 2010; Kemabonta and Falodu 2013; Kossou 1989). Only 1 out of 8 times did it fail to supply electricity, maybe due to the insufficient number of neem leaves utilised.

The Neem plant (Azadirachta indica A. Juss Fam. Meliaceae) is widely used in Nigeria's north central area for agriculture and home pest control, medicinal applications, and shade trees. According to Ezekiel et al (2008), it has been used in local mythology to protect crops and dwellings from pests and infections. Azadirachta indica (neem tree) contains terpenoids such nimbin, azadirone, and

azadirachtin, which have antibacterial characteristics. Azadirachtin is produced from both the fruits and leaves of this plant. It also works as an insect repellent, preventing insects from reproducing.

Obongoya et al. (2010) found that greater doses of Azadirachta indica greatly decreased conidia formation and proliferation. (The length of the haustoria is 1-2mm). Fusarium inhibition was also seen at lower doses. Compared to the other three crude plant extract formulations, Azadirachta indica significantly reduced wilt incidence.

Neem spray suppresses mycelial development in the vascular system by translocating it throughout the plant (Gupta et al., 1999; Vyas et al., 1999). Studies suggest that neem may effectively monitor Fusarium yellows disease on farms. At low and high doses, it greatly suppresses conidia generation and proliferation. Azadirachta indica, a natural botanical pesticide with minimal toxicity to people and animals, may effectively control plant pests in IPM programmes for subsistence farmers. Suleiman and Emua (2009) found that aqueous extracts of Azadirachta indica have variable degrees of toxicity to P. aphanidermatum, a fungus that causes root rot in cowpeas (Vigna unguiculata). According to Paul and Sharma (2007), bavistin (carbendazim) and an aqueous extract of neem (Azadirachta indica Juss.) leaves were equally efficient in suppressing the leaf stripe pathogen (Drechslera graminea) on barley.

Garlic (Allium sativum) Extract:

Ingredients: Garlic bulbs (30gm). 30g of garlic bulbs were finely crushed in a grinder with 50ml of water. The ground mixture was soaked in a little amount of water overnight and pressed through a muslin cloth. The volume was increased to 1L by adding water and spraying.

Garlic cloves have pesticidal efficacy due to sulphur-containing chemicals produced by allicin degradation (Huang et al. 2000; Prowse et al. 2006; Yang et al. 2012; Zhao et al. 2013). Garlic extracts have been shown in laboratory trials to have acaricidal properties (Dąbrowski and Seryńska 2007; Roobakkumar et al. 2010) and insecticidal properties against coleopteran, dipteran, lepidopteran, and hemipteran pests (Abdalla et al. 2017; Denloye 2010; Prowse et al. 2006; Yang et al. 2012; Zhao et al. 2013). Garlic aqueous extracts showed varying levels of control for hemipteran pests (Bahar et al. 2007; Baidoo and Mochiah 2016; Fening et al. 2013; Oparaeke et al. 2007; Said et al. 2015), lepidopteran pests (Baidoo and Mochiah 2016; Fening 2013; Oparaeke et al. 2007), and mites (Attia et al. 2011). Garlic-based insecticides have been shown to prevent mites on tomatoes (Kaputa et al. 2015) and fruit flies on watermelon (Degri and Sharah 2014), but no statistical testing was conducted.

Allium sativum (garlic) has a potent antibiotic called allicin. Alicina is effective against a wide spectrum of bacterial species at 1:10 dilutions. Most bacteria are vulnerable to it. Garlic extracts are efficient against fungus species and may preserve plants and stored goods (Stoll, 1998). In studies by Jacob and Siva Prakasan (1994) and Arya et al. (1995), extracts of several plant species were shown to have antifungal action against Fusarium pallidoroseum. Extracts of garlic bulbs and Bignonia

leaves inhibited Fusarium pallidoroseum mycelial growth. The greatest concentration of A. sativum extract significantly reduced Fusarium pallidoroseum spore germination. In addition, A. sativum has anti-fungal properties (Sahayaraj et al., 2006). Misra and Dixit (1976) and Bowers and Locke (2000) showed similar results when employing Allium sativum against 18 different fungus, including Fusarium spp. (Taskeen-Un-Nisa et al 2011).

Extract of garlic and chilli (Capsicum annum)

Materials needed: 30g green chilli and 30g garlic.

Garlic bulbs and green chilies (30g each) were crushed separately in a grinder with a little water. To get a 3 percent concentration, grinded material was soaked in water overnight and the extract was pressed using a muslin cloth. The mixture was then combined and diluted to 1L.

Capsaicin is the main chemical responsible for the spiciness of chilli peppers. Commercial insecticides containing capsaicin are widely accessible. Capsaicin may repel and kill hemipterans (Bergmann and Raupp 2014; Dayan et al. 2009). Antonious et al. (2006, 2007) found that other chemicals may enhance the insecticidal properties of chilli pepper formulations. Aqueous extracts of chilli pepper have been utilised to control hemipteran pests (Amoabeng et al. 2013; Baidoo and Mochiah 2016; Fening et al. 2013, 2014; Okrikata et al. 2016) and lepidopteran pests (Amoabeng et al. 2013; Baidoo and Mochiah 2016; Fening et al. 2013, 2014; Okrikata et al. Five out of ten times, chilli pepper aqueous extracts outperformed negative controls. In four out of five studies where chilli pepper aqueous extracts were unsuccessful, the synthetic pesticides employed as a positive control were similarly ineffective (Fening et al. 2013, 2014), suggesting that the results are not conclusive.

Ground chilli pepper fruit outperformed the cowpea weevil Callosobruchus Maculatus in two investigations (Onu and Aliyu 1995; Yusuf et al. 2011), but failed in a third (Boeke et al. 2004b). Farmer participation trials in Ghana over 5 years confirm the efficiency of this practice (Belmain and Stevenson 2001). Belmain et al. (1999) reported that chile pepper effectively kills and repels weevils that attack stored grains, however the article did not provide specific data.

Ginger (Zingiber officinale Roscoe).

Zingiber officinale (ginger) includes gingerols and polyphenol chemicals (antioxidants) with various therapeutic effects. Stoilova et al. (2007) found that the rhizome is efficient against many pest crop diseases. Plant species such as Piper, Xylopia, Gongronema, Latifolium, Citrus, Bryophyllum, Pinnatum, Vernonia amygdalina, Chrysanthemum, and Ocimum have shown potential for crop protection (Jacobson, 1989; Stoll, 1998, 2000; Okonkwo, 2001; Opara and Wokocha, 2008).

In 2010, Opara and Obani studied the efficacy of plant extracts and insecticides for managing bacterial spot infections in solanum. The investigation revealed that Z. officinale outperformed three other extracts and the control (sterile water) in terms of controlling the severity of the disease. Plant extracts have bactericidal effects on Solanum's leaf spot disease, supporting Stoll's (1998) and

Amelio's (1999) findings that they possess significant antibacterial and therapeutic characteristics. Bankole (1997) suggests that the efficiency of plant extracts may be due to the bioactivity of their ingredients.

Indigenous botanical sprays used by the farmers to control insect pests in crops.

Botanical Preparation	Target Pests
Neem leaf extract	Defoliators and Sucking pests
Garlic extract	Spodoptera litura (leaf eating caterpillar), Helicoverpa armigera (fruit borer), and other lepidopteran pests
Garlic-Chilli-extract	Helicoverpa armigera (fruit borer), Spodoptera litura (leaf eating caterpillar), Leucinodes arbonalis (Brinjal fruit & shoot borer), Amsacta albistriga (red headed hairy caterpillar)
Fermented botanical spray	Leucinodes orbonalis (Brinjal fruit and shoot borer), Pod borers of pulses, Tobacco caterpillar (Spodoptera litura)
Adathoda vesica leaf extract	Defoliators and Sucking pests
Datura plant extract	Tea mosquito bug, Thrips, Jassids, Aphids
Ekka leaf extract	Termites
Lantana leaf powder	Aphids
Lantana leaf extract	Beetles, Leaf miners, Defoliators
Mixed leaves extract	Defoliators like Spodoptera litura, semi-loopers
Panchapatre	Defoliators, Fruit borers, Sucking pests like Aphids and Whiteflies
Nilgiri leaf extract	Jassids, Aphids, Scales
Chilli Neem Garlic extract	Lepidopteran pests in Pigeon pea
Multiple plants leaf extract	Multiple pests

Allelochemical activities of some natural plants (Botanicals)

Name of Plant	Allelochemical	Action
Bambusa vulgaris (Bamboo)	Rutin, Tricin, Luteolin	Controlled small grassy weeds; Pesticide effects
Calotropis gigantea (Akanda)	Calotropin and Mudarine	Controlled most small grassy weeds; Pesticide effects
Carica papaya (Papaya)	Benzyl isothiocyanate	Herbicide effects
Echinochloa colona (Jangli dhan)	Cumaric acid, Apigenin, Benzoxazinoids	Potential use for monocot grassy weed control
Lantana camara (Lantana)	Lantradene-A	Weed control; Pesticide effects
Oryza sativa (Paddy wild cultivars)	Momilactone B	Control grassy weeds like Echinochloa spp.
Parthenium hysterophorus (Congress grass)	Sesquiterpene lactones & Phenols	Control small grassy weeds
Pinus sylvestris (Pine)	Terpene hydrocarbons, Ethers and esters	Non-selective herbicide, not as effective as glyphosate
Sorghum halepense (Johnson grass)	High prussic acid; Sorgoleone	Suppress the weed growth
Syzygium aromaticum (Clove)	Eugenol, Caryophyllene, and Acetyl eugenol	Controlled most small grassy weeds; Pesticide effects
Tectona grandis (Teak)	Phenols, Salicylic acid	Controlled small grassy weeds; Pesticide effects

Natural products as herbicides.

Weeds develop resistant to herbicides like glyphosate, making natural products a viable alternative (K. Jabran et al., 2015). Plants and microbes are the primary suppliers of secondary metabolites, which have numerous agricultural uses. Allélopathic plants emit chemicals that impact the development, nutrition uptake, and reproduction of other species. Plants having strong allelopathic activity are often used for weed management, according to studies. Recent research suggests that rough extracts may effectively suppress weed development in several plant sections (R. A. El-Mergawi et al., 2019). Melaleuca cajuputi extract contains active compounds such as caryophyllene, eugenine, and humulene, which have therapeutic qualities (B. W. B Kueh et al., 2019). Mikania micrantha root

extracts included four novel thymol compounds with allegopathic properties (Q. Xu, H. Xie, H. Xiao, et al., 2013). The leaf extracts of five Amaranthus species contain nine active components.Coumarin and saponins were shown to have allelopathic effects on lettuce (Carvalho, Andrade-Vieira et al., 2019). Bioachanine A, an essential isoflavone, has been demonstrated to have phytotoxic effects on dicotyledons and monocotyledons, including Amaranthus caudaus L. and Echinochloa crusgalli L. The biochanin A degrading agent is phytotoxic to the same animal (Shajib, Pedersen, Mortensen et al., 2012). Extraction of chalepin and chalepensin from Ruta graveolens and Horta oreadica effectively inhibited the growth of Allium cepa, Lepidium sativum, and Lycopersicon esculentum, outperforming synthetic herbicides (Nebo et al., 2014). G. al-Samarai, W. Mahdi, B. al-Hilali et al. (2018) found that a watery extract effectively prevented Cyperus rotundus L growth. L., Nerium Oleander L., Olée europäea L., Ricinus communis L., and synthetic herbicides (tebenuron) were all employed. The N. oleander extracts had the strongest inhibitory activity compared to the other two extracts and synthetic herbicide.

Natural products as fungicides.

A variety of plant extracts have proven effective as fungicides. Leaf extracts from Azadirachta indica (A. Akpuaka, M. M. Ekwenchi et al., 2013), Curcuma longa (H. Masih, J. K. Peter and P. Tripathi et al., 2014), and Ipomoea batatas Lam peels (A. P. Oluyori, A. K. Shaw et al., 2016) are examples. M. Camara, E. Faie, S. Modou Sarr et al. (2017) and R. Persaud, A. Khan, W.-A. Isaac, W. Ganpat, and D. Saravanakumar et al. (2019) used papaya, thyme, and lemongrass extract. Azadirachta indica leaf extract contains crude extracts of dibutyl phthalate, phytol, nonanoic acid, tritriacontane, and 1,2-benzedicarboxylic acid (A. Akpuaka, M. M. Ekwenchi et al., 2013). The peels of Ipomoea batatas Lam. show acceptable growing activity. Sporothrijschencki and Trichophyton metagrophytes fungus contain three compounds: stigmasterol, three-friedelanol, and urs-13(18)-ene-3β-yl acetate (A. P. Oluyori, A. K. Shaw, R. Preeti, 2016). Thyme and lemongrass extract effectively combated sheath blight disease in rice, improving crop development and grain output (R. Persaud, A. Khan et al., 2019). These extracts produce essential oils, saponins, tannins, flavonoids, and other phenolic chemicals (I. Owis et al., 2015). Curcuma longa leaf extract has been demonstrated to effectively suppress Aspergillus fumigatus at 6.25 µg/ml and Helminthosporum spp. at 12.5 µg/ml (H. Masih, J. K. Peter, and P. Tripathi, 2014).

Pink root disease, caused by the fungus Pyrenochaeta terrestris (Hansen), is a difficulty for onions in nursery settings. Extracts from A. indica and C. papaya leaves effectively inhibited the fungal illness compared to synthetic fungicides. A. indicica and C. papaya leaves may be used in antipathy as a cost-effective and ecologically sustainable alternative (M. Camara, E. Faye et al., 2017).

Natural Products as Insecticides.

Botanicals have been successfully investigated to battle pest infestations in a healthy, cost-effective, and sustainable manner. Plant extracts have strong insecticidal effects. The following extracts have

been studied: Carica papaya seed extract (K. Konno, C. Hirayama, M. Nakamura et al., 2004), Persea americana Mill seeds, peels, and pulp (R. C. Torres, A. G. Garbo et al., 2014), Clausena lenisJ. stem and leaf extract (G. Scott, N. Liu, and Z. Wen 1998), Cal (R. Larayetan, Z. S. Ololade et al., 2019), and Azadiirach. The active ingredients in any of these insecticidal extracts are clearly visible. Phytochemicals in these extracts play a key role in the observed occurrences, and their processes have been explored. According to M. A. Hossain, W. A. S. Al-toubi, et al. (2013), extracts of the tree's leaf, bark, and seed contain several components. Azadirachtin is an important component of neem seeds in particular. Azadirachtin's insecticidal properties disrupt feeding, development, synthesis, and delivery of moulting hormones (ecdysteroids), leading to sterility in adult female insects and deficient moulting in young insects (M. B. Isman et al., 2006). According to A. Onekutu et al. (2015), the product is gentle on vertebrates, burrowing agents, caterpillars, whiteflies, mealy bugs, and weevils, as well as beneficial insects including ladybirds, bees and spiders. Azadirachtin's diverse effects led to the development of organic insecticides derived from the neem tree, including Agroneem, Azatrol EC, and Ecozin (M. B. Isman et al. 2006). Ethanol extracts from A. mucosa seeds contain acetogenins, which have insecticidal properties. Acetogenins block plasma membrane enzymes and mitochondrial arthropod transport systems L. (Ribeiro, Zanardi, et al., 2014).

Conclusion

Alternative management approaches are used to address challenges such as chemical pollutants, biodegradation, phytotoxicity, and pollution from chemical control tactics. Plant extracts are a cost-effective, accessible, specific, ecologically friendly, and human-safe alternative to synthetic substances in treating plant diseases. Farmers should be encouraged to employ plant extracts for sustainable agricultural and horticulture output. Botanicals provide benefits such as biodegradability, structural variety, and safety for nontarget species. To fully use the potential of eco-friendly botanical extracts, it's crucial to promote their usage in rural markets. This requires extensive knowledge and training courses.

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