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Disastrous impact of weeds on field crops

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Abstract
Presence of weeds increases the expense of agriculture and inhibits the progress of operations. It increases the watering need. They lower the worth of the produce or increase the cost of cleaning in some way. When certain weeds (*Cleome viscosa*) are consumed by dairy cows, they produce an unpleasant odour in the milk. Weeds increase the expense of agriculture and impede job progress. It increases the amount of water that must be irrigated. They lower the worth of the produce or increase the cost of cleaning in some way. When dairy animals eat some weeds (*Cleome viscosa*), the milk develops an unpleasant odour. It is possible that death, dysfunction, or deformity will ensue. *Datura strumarium*, for example. For about half of India's population, agriculture is the primary source of income. However, crop production is substantially lower than in many other nations, and it must be improved in order to produce 400 million tonnes of food grains by 2050 to meet the needs of a population of 1.7 billion people. In India, the diverse climatic conditions encourage the most widely used weeds to thrive and inflict serious crop productivity losses. Weeds also decrease food quality, boost production costs, and house and serve as alternate hosts for a variety of insect pests and diseases. Many important weeds of concern today in India are *Parthenium hysterophorus* L.; *Phalaris minor* Retz. *Leptochloa chinensis* (L.) Nees; *Echinochloa* spp.; weedy rice; *Lantana camara* L.; *Chromolaena odorata* (L.) R.M. King & H. Rob.; *Mikania micrantha* Weed control in India is crucial for increasing crop productivity by reducing weed-caused crop yield losses and alleviating other weed-related negative consequences in various ecosystems. Weeds continue to be a problem in a variety of ecosystems, despite advances in weed management technology for diverse crops and ecosystems. The real challenges in Indian weed research are: managing weeds in small farms; lack of labour and mechanical tools; insufficient information on weed biology and shifts in weed flora; herbicide resistant weeds; lack of understanding of the impact of climate change on weeds and weed control. This review analyses these issues and suggests measures ensuring safe use to avoid adverse effects.

Keywords: Weeds, ecosystems, weed management, crop productivity

Introduction

India has a vast population and an agrarian economy. Agriculture provides jobs, food security, and industry goods and services need. Temperatures range from arctic cold to equatorial heat, and rainfall ranges from extreme aridity (ten centimetres per year) to extreme humidity, with certain locations receiving the world's greatest rainfall (1120 centimetres per year).

The country is divided into 20 agro-eco regions and 60 agro-eco-sub-regions based on soil, bioclimate, and physiography. At the district level, each agro-eco-sub-region has been further divided into agro-eco-units in order to construct long-term land use strategies (Gajbhiye and Mandal, 2006). Agriculture contributed 17.9% to the Gross Domestic Product (GDP) in 2014-15 at constant prices (2011-12).

Employment in the agriculture sector accounts for 48.9% of the total workforce (ILO, 2016). India's population is predicted to reach 1.7 billion people by 2050, with food demand expected to climb to 400 million tonnes. India has to enhance productivity in agriculture to ensure food security for the growing population. Therefore, the Indian agricultural production system has challenge to feed l7.5% of the global population with only 2.4% of land and 4% of the available water resources at its disposal. India is the world's second largest producer of rice, wheat, and cotton, after China and the second largest producer of sugarcane, after Brazil. India is also the second largest producer of horticultural products in the world. But the productivity of crops is much lower than many countries and needs to be enhanced to meet the demands of increasing population.

Weeds are responsible for roughly one-third of all agricultural pest losses (DWR, 2015). As a result, initiatives in India to improve agricultural output should include measures to reduce weed-related losses.

Weeds are the most serious and pervasive biological limitation to agricultural production systems, causing harm to both cropped and non-cropped fields. They diminish agricultural productivity and damage product quality while also increasing production costs. Weeds not only lower land value by reducing production and nutrient losses, but they also house and act as alternate hosts for a variety of insect pests and illnesses. Weeds also pose a health risk and reduce biodiversity in non-cropped regions. Despite advances in weed science research and extension, Indian farmers continue to suffer significant crop yield losses due to weed interference. Weed losses in agricultural crops vary because the nature, size, and severity of weed problems are dependent on the ecology in which the crop is cultivated, as well as factors including hydrology, land topography, the surrounding environment, establishment methods, and cultural practices. The crop loss estimates are often misleading as scientific estimates are yet to be done. Even the most conservative loss estimate of 10% would result in a loss of nearly 25 Mt of food grains, valued at almost US$ 13 billion (Yaduraju, 2012). Similar losses may occur in plantation crops, fruits, vegetables, grasslands, forests, and the aquatic environment. The total economic costs will be significantly higher if the indirect consequences of weeds on health, biodiversity loss, nutrient depletion, grain quality, and other factors are taken into account. Weeds have grown to alarming proportions in several sections of the country. Weed concerns are unique to each agro-ecological location and crop cultivated (Rao *et al.*, 2014). It is critical to manage weeds in order to avoid grain losses, decrease soil fertility and productivity, make more rational and judicious use of natural resources such as sunlight, water, and land, and increase crop productivity. Recognizing the relevance of weeds, early studies on weed management in Indian agroecosystems were conducted. (Joshi, 1971; Mukhopadhyay, 1993; Bhan and Sushilkumar, 1998; Yaduraju, 2012; Rao and Chauhan, 2015; Singh *et al.*, 2016).

Recent discoveries on weeds and weed management in India's many ecosystems are integrated in this overview, which also lists the problems and opportunities in weed management research in India.

History of weed research in India

Weeds have been present on the planet since the beginning of time, as they have adapted to various types of habitats and thrive in the right ones. Farmers used repeated tillage, manual weeding, cover crops, grazing, rotation, burning, and flooding in rice to control weeds in the past. In India, sodium arsenite was originally employed in 1937 to manage Carthamus oxicantha in Punjab (Rao *et al.*, 2014). In India, 2,4-D was first introduced in 1948 (Mukhopadhyay, 1993), and numerous chemicals were imported and tested. Certain weeds were effectively controlled by some of them. In India, scientific research on weed management began in 1952 with the establishment of an all-India coordinated research strategy on main crops such as rice, wheat, and sugarcane. Weed control was established in the Division of Agronomy at the Indian Institute of Agriculture Sciences in New Delhi, India, in the same year (1952). The first agricultural university was created in Pantnagar, Uttar Pradesh, in 1960, and since then, several agricultural universities have been constructed around the country, with Weed Science as part of the curriculum and weed science research being conducted. All India Coordinated Research Project (AICRP) on Weed Control was initiated in 1978 with funding from USDA-PL480 project funds, with a few centers initially and expanded to several centers in different states of India (Bhan and Sushilkumar, 1998). National Research Centre for Weed Science was established in India during 1989 at Jabalpur, Madhya Pradesh which was upgraded as Directorate of Weed Science Research in 2009 and renamed as Directorate of Weed Research (DWR) in 2014 (DWR, 2015). Since its inception, the institute is engaged in basic and strategic research on weeds and weed management. It also coordinates location-specific weed management research carried out at 23 coordinating units located at different parts of the country. DWR has been successful in bringing awareness about the importance of weeds and weed management in enhancing crop productivity and sustainability. In 1968, the "Indian Society of Weed Science" (ISWS) was established and ISWS started publishing Indian Journal of Weed Science since 1969 and is continuing successfully till to date (Chandrasena and Rao, 2017). 3. Weeds of India and losses caused Weeds (terrestrial, parasitic and aquatic) interfere with crops cultivation and ecosystem resilience in addition to loss of biodiversity (displacement of native plant species), potentially productive land, grazing land and livestock production.

The number of most frequently encountered weed species in Indian agriculture varied from 60 to 70 in humid, per-humid, subhumid, coastal, and island ecosystems, 30–40 in semi-arid, and 15–20 in arid ecosystems, according to data collected over a 20-year period from various Indian agro-ecological regions (Dixit *et al.*, 2008). Weeds have been observed to reduce yields by 5% in commercial agriculture, 10% in semi-commercial agriculture, 20% in subsistence agriculture, and 37–79% in dry land agriculture (Choudhury and Singh, 2015). (Singh *et al.*, 2016). A Weed Atlas for major weeds in major crops in 435 districts spread across 19 states of the country was published by DWR (Dixit *et al.*, 2008). In India, 826 weed species were found to cause yield losses, with 80 and 198 being classified as extremely dangerous and serious weeds, respectively (Choudhury and Singh, 2015). In the DWR's vision paper, the major weed species of India were listed in various conditions (DWR, 2015). The following are the most common weeds:

Crop lands: *Phalaris minor* Retz. *Echinochloa crus-galli* (L.) P. Beauv., weedy rice, *Ageratum conyzoides* L., *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers. and *Parthenium hysterophorus* L. Non-crop lands: *P. hysterophorus*, *Lantana camara* L., *Mikania micrantha* Kunth., *Mimosa invisa* Martius ex Colla, *Ageratum haustonianum* Mill., *Saccharum spontaneum* L., *Chromolaena odorata* (L.) R.M. King & H. Rob. And *Alternanthera sessilis* (L.) R. Br. ex DC. *Eichhornia crassipes* (Mart.) Solms, *Salvinia molesta* Mitch, *Hydrilla verticillata* (L.f.) Royle, *Typha angustata* Bory & Chaub., and *Alternanthera philoxeroides* (Mart.) Griseb. Are the major aquatic weeds of concern in India? Parasitic weeds: Parasitic weeds are infesting crops, ornamental plants, hedges, and trees in numerous Indian states, inflicting economic losses. *Orobanche cernua* Loefl. (On tobacco, tomato, and potato), *Striga asiatica* (L.) Kuntze (on maize, sorghum, and pearl millet), *Cuscuta reflexa* Roxb. (On niger, greengram, blackgram, berseem, lentil, and linseed chickpea), and *Dendrophthoefalcata* (L.f.) Ettingsh. (On neem, mango)

Methodology

Materials and Methods

Selection of the plants

Aqueous extracts of leaves of *Hyptis sauveolens* (L.), *Ricinus communis* (L.), *Alternanthera sessilis* (L.), *Ipomoea carnea (Jacq)*, *Malachra capitata* (L.) and *Cymbopogon citrutus (Stapf)*, were studied for their effects on seed germination on

Triticum aestivum (L.) i.e. wheat.

Plant sampling and preparation of extracts

Water was used to wash the leaves numerous times. Local leaves were gathered, dried in the oven, crushed, and sieved. Water extracts of the cannabis powder were made and stored in bottles at 1 percent, 2 percent, 3 percent, and 5 percent concentrations. During the 48-hour period, the bottles were shaken every 24 hours. The extracts were filtered and stored in dark vials after being filtered with muslin cloth.

Seed germination studies

In a Petri dish (9 cm diameter), ten surface sterilised seeds of *Triticum aestivum* (L.) were put on double-layered Whatman filter paper No. 1. The filter paper was soaked with 5mL of different weed extracts at concentrations of 1, 2, 3, and 5%. Each treatment was replicated three times in a thoroughly randomised method. Seeds were incubated at 20°C2 and moisture levels in Petriplates were measured on a regular basis. For biochemical studies, the complete seedling was utilised to estimate total protein (Lowrys *et al.*, 1951) [19], and the cotyledons were used to estimate total chlorophylls (Arnon, 1949) [1]. Water was used to set up a distinct control series. Every day for seven days, around two cc of extract or water was added to the petri dishes to keep them moist. The final germination %, weight of germinated seeds, radicle, and plumule length were all measured on the seventh day. The Seed Vigor Index (SVI) was calculated by multiplying percent germination by average radicle length (Abdul and Anderson, 1973). Water was used to keep a control by watering the seeds. The mean values were compared using a statistical analysis utilising the students T Test.

Table 1: Effect of various concentrations of aqueous weed extracts on radicle length of *Triticum aestivum* after 7 days in cms.

Concentration of extract	Ipomoea	Cymbopogon	Ricinus	Hyptis	Malachra	Alternanthera
0	4.79	4.793	4.793	4.793	4.793	4.793
1	2.8	3.463	3.289	4.463	4.493	3.4
2	0.51	3.38	3.2	3.393	4.404	3.09
3	0.68*	2.87	2.966	3.233	4.025	2
5	0.23*	1.93	3.482	2	3	2

*Significant at $P < .05$. Values are mean of 60 samples

Table 2: Effect of aqueous extract of the basil leaves on quantitative and biometric parameters

Plant species	Concentration of aqueous extract, %	Germination of test seeds, %	Germination compared to the control, %	Length, cm	Weight, g
Wheat (*Triticum aestivum* L.)	0%	86%	-	19.7 cm	118.2 g
	1.25%	75%*	87%	11.3* cm	99.1* g
	2.5%	43%*	50%	5.5* cm	43.3* g
	3.75%	2%*	3%	1.4* cm	6.8* g
	5%	0%*	-	-	-
Johnson grass (*Sorghum halepense* (L) Pers)	0%	88%	-	4.1 cm	35.7 g
	1.25%	61%*	69%	3.5* cm	22.9* g
	2.5%	27%*	31%	2.2* cm	15.5* g
	3.75%	5%*	6%	1.4* cm	2.8* g
	5%	0%*	-	-	-
Twitch (*Cynodon dactylon* L.)	0%	93%	-	3.6 cm	29.4 g
	1.25%	21%	23%	2.0 cm	6.3 g
	2.5%	0%	-	-	-
	3.75%	0%	-	-	-
	5%	0%	-	-	-
White pigweed (*Chenopodium album* L.)	0%	85%	-	3.5 cm	26.0 g
	1.25%	7%	8%	0.4 cm	3.5 g
	2.5%	0%	-	-	-
	3.75%	0%	-	-	-
	5%	0%	-	-	-
Curly dock (*Rumex crispus* L.)	0%	98%	-	6.8 cm	66.5 g
	1.25%	91%	93%	5.5* cm	58.8 g
	2.5%	56%*	57%	4.2* cm	31.0* g
	3.75%	23%*	24%	2.5* cm	19.1* g
	5%	0%*	-	-	-

A similar experiment was carried out to see if weeds have a deleterious impact on wheat (*Triticum aestivum* L.). For this investigation, we used wheat seeds (*Triticum aestivum* L. type Sadovo 1) and the most common weeds discovered in it: Sorghum halepense (L) Pers) is a kind of Johnson grass.White pigweed (*Chenopodium album* L.)

- Twitch (*Cynodon dactylon* L.)
- Curly dock (*Rumex crispus* L.)

Weed seeds were collected on the field in the autumn of 2013, after they had matured, following purchasing wheat seeds from a certified producer. Before beginning the allelopathic experiment, the viability of the collected weed seeds was examined, and the percentage of germination for the four species was above 85%.

The germination of white pigweed seeds was significantly reduced by an aqueous extract of basil leaves, with a reduction of up to 92 percent at the lowest test dosage. Twitch was also shown to be particularly sensitive, with a 77 percent suppression of germination. Wheat germination was marginally impacted by the lowest test concentration of aqueous basil extract, but germination was reduced by half at the following one. Curly dock seeds were relatively resistant to the effects of basil, surviving in the presence of three times the amount of basil extracts in the grow medium. The data showed that as the content of basil extract was increased, germination, growth, and biomass production in the Johnson grass, curly dock, and wheat decreased significantly (p0.05).

We may conclude that peppermint is not ideal for allelopathic active species in wheat crops, based on the high sensitivity of wheat seeds and young plants.

Chenopodium album L. is a weed that grows in wheat, other arable crops, and orchards. Cases of *C. elegans* resistance Since 1980, various European countries and the United States have reported adverse reactions to herbicides such as atrazine, metribuzin, and linuron (Eleftherohorinos *et al.*, 2000). As a result, research on alternate eco-friendly means of control has accelerated. Anjum & Bajwa (2007) conducted preliminary investigations that revealed the vulnerability of broadleaved weeds like C. sunflower extracts album. The crude extract failed to entirely eradicate this weed when compared to synthetic herbicides, but the highest tested dose successfully killed the weed and overcame weed crop competition, resulting in a considerable improvement in wheat production. C. album seeds were shown to be highly sensitive to both basil and lavender aqueous extracts in our research, with germination being nearly completely reduced at the lowest test dosage of 1.25 percent extract. Seed germination was similarly inhibited by extracts from spearmint and peppermint leaves, but only at concentrations more than 3.75 percent. *Cynodon dactylon* and *Sorghum halepense* are two C4 perennial grasses that are among the worst weeds on the planet (HOLM *et al.*, 1977). Sorghum halepense reproduces both by seed and by rhizomes, but *Cynodon dactylon* propagates primarily vegetatively through stolon and rhizome fragmentation (HOROWITZ, 1973). Both weeds' rhizomes are their primary sources of carbohydrates and dormant buds for overwintering. A single plant of Sorghum halepense can produce 40 to 90 m of rhizomes per growing season, whereas the fresh weight of subterranean parts down to 45 cm of *Cynodon dactylon* can range from 420 to 780 g m-2 in a single year. Also, because mechanical tillage of weed-infested fields fragments and disperses rhizomes propagules, from which new ramets can be generated, rhizomes are the principal mechanism of *Cynodon dactylon* and Sorghum halepense dispersion in the field (FERNANDEZ, 2003; MITSKAS *et al.*, 2003).

The allelopathic potential of residues from some brassica species, including round white radish (*Raphanus sativus* L.), garden radish (*Raphanus sativus* L.), black radish (*Raphanus sativus* L. var. niger), little radish (*Raphanus sativus* L. var. radicula), turnip (*Brassica campestris* L. subsp. rap (2009). In the field and in the lab, all of these species inhibited Johnson grass. Lavender and peppermint were shown to be the most effective plant species against Johnson grass, reducing seed germination by up to four times at 1.25 percent aqueous leaf extract and entirely suppressing it at higher levels. Seeds were similarly by basil and spearmint leaf extracts.

Detrimental effect of weeds on Yield performance

According to Bhalerao *et al.* (2011) [10], the weed free treatment followed by two hand weeding and hoeing at 15 and 30 DAS and pre-emergence pendimethalin followed by one hand weeding at 30 DAS had the highest value of yield attributes (total number of developed pods, hundred pod and hundred kernel, test weight, shelling percentage, and volume weight). Similarly, Olayinka and Etejere (2015) [51] found that rice straw mulch + one hand weeding at 6 WAS produced the most matured pods per plant, seed weight per plant, 100 seed weight, pod yield, seed yield, and harvest index of all the treatments. Weedy check had the lowest yield components and yield. Weed competition caused a 100 percent yield reduction in both rice cultivars when compared to weed-free conditions, with yields of 6.39-6.80 t ha-1 for cultivar PR 114 and 6.49-6.87 t ha-1 for cultivar PR 115. (Singh *et al.*, 2014) According to Faryadras and Farnia (2014) [25], the weed-free control had the maximum ear weight (260 g), 1000 kernel weight (356.67 g), number of kernels in ear (785.33), biological yield (56800 kg ha-1), and grain yield (56800 kg ha-1) (16660 kg ha-1). The weed competition treatment with whole season weed competition had the lowest ear weight (160 g), 1000 kernels weight (236.67 g), number of kernels in ear (380.5), biological yield (27400 kg ha-1), grain yield (5525 kg ha-1) and harvest index (20.36 percent). Weed management up to 10 days after emergence in maize yielded the highest harvest index. Weed competition has a considerable impact on fababean grain production and yield contributing features. The weed-crop competition could be over in 45 days.

Study on weeds

Increasing the population of weeds in a specific region allows them to more efficiently use resources and boost their growth and development while reducing crop availability in the same space. Weeds, grasses, broad-leaved weeds, and sedges all compete with crops in different ways. Knowing the diverse weed floras, weed density, and dry matter holdings is necessary for improved weed control.

Weed flora

Weed infestation causes around 40% of crop yield loss. Weeds vary from location to place and season to season, thus it mostly depends on the kind, species, and density of weeds growing in a crop community. According to Singh *et al.* (2014), the most common weed species in rice fields were *Cyperus rotundus* and *Cyperus compressus* among sedges; *Echinochloa crus-galli*, *Echinochloa colona*, *Dactyloctenium aegyptium*, *Digitaria ciliaris*, *Eragrostris* spp. among grass weeds; *Euphorbia hirta*, *Phyll Eleusine indica*, *Rottboellia cochinchinensis*, *Digitaria ciliaris*, *Echinocloa colona*, and *Rottboellia cochinchinensis* are all similar. Mehrotra *et al.* (1984) reported that the major weeds associated with sunflower on sandy loam soils of Kanpur were, *Cyperus rotundus, Spergula arvensis, Anagallis arvensis, Melilotus* sp., *Convolvulus arvensis, Asphodelus tenuifolius, Launaea asplenifolia*, and *Chenopodium album.*

Weed Density and its dry matter production

The maximum weed densities in black seed (*Nigella Sativa* L.) were recorded at 42 days after emergence in both years of the experiment, according to Seyyedi *et al.* (2016) [58]. Total weed density was found to be higher in the first year (384 plants m-2) than in the second year 42 days following seedling emergence (312 plants m-2). The leading weed species were, however, relatively similar in both years.

Preventing and managing invasive weeds

In India, 173 invasive alien species from 117 genera and 44 families were reported, accounting for 1% of the country's flora (Reddy, 2008). The majority of them came from tropical America (74%) and tropical Africa (14%) respectively (11 percent). Non-native organisms that cause or have the potential to cause harm to the environment, economy, or human health are known as invasive alien species. The following invasive exotic weeds have been documented from India and are of particular concern: *P. hysterophorus*, L. camara (Nanjappa *et al.*, 2005), A. conyzoides (Bajwa *et al.*, 2016), *E. crassipes*, M. micrantha (Banerjee and Dewanji, 2012) and *P. minor* (Mahajan and Brar, 2001) as they are troublesome and have caused immense adverse ecological, economic and social impact. They have invaded a variety of settings and can be found in abundance on road sides, in woodlands, and in farmed regions. *P. hysterophorus* is the most bothersome and toxic plant, which has rapidly colonised urban areas, displacing native flora and creating a variety of human health issues (skin allergies, rhinitis, and eye irritation among nearby individuals) (Bajwa *et al.*, 2016). *P. hysterophorus* is bitter and poisonous to cattle. *P. hysterophorus* has now become a serious weed in India's highland crops. In the Indian forests, L. camara has infiltrated wider amounts of land, displacing forest floor vegetation and reducing tree growth. *Ageratum conyzoides* is a major weed in agricultural fields that competes with crops, resulting in significant yield losses in India's principal crops. When it invades rangeland areas, it outcompetes natural grasses in infested rangelands, resulting in a lack of feed. These weeds have comparable growth methods that make them successful invaders of native ecosystems, such as quick growth rates, short life cycles, higher reproductive capacity, high competitive abilities, and allelopathy.

Conclusion

Weeds are the most hazardous terrorists, causing the greatest yield losses. From germination till harvesting, it has an impact on the crop. During the early stages of crop growth, the majority of weed flora and density produce higher losses. Increased weed competition time boosts both crop and weed competitiveness while lowering physiological elements of growth and development, yield characteristics, and yield of a specific crop. Weed control at the vital period of crop weed competition is cost-effective, saving money on chemicals and time. Weed extracts of all plants with concentrations between 3% and 5% exhibited a negative impact on all of the parameters evaluated. Seed vigour index showed a significant drop, and it followed the trend. *Alternanthera sessilis* > Cymbopogon strictus > Ipomoea carnea> Hyptis saveolens >Malachracapitata> Ricinus communis> Ipomoea carnea and *Alternanthera sessilis* weed extracts exhibited the strongest allelopathic effect on Wheat seed germination. In the seven-day seedlings, total proteins, as well as total chlorphylls, exhibited a significant decrease in all concentrations of weed extracts. The severity of the weeds in terms of growth was reflected in the germination parameters and physiological development of all weed extracts. Field trials would help researchers better understand how weeds affect plant productivity.

The aqueous extract of lavender flowers had the most unfavourable impact on the germination of all test seeds and the development of young plants among the allelopathic active plant species employed in this investigation. Even at low quantities, spearmint leaves had a significant inhibitory effect on the germination of the weed species examined, while wheat seeds were just minimally affected.

As a result, we can state that lavender is unsuited for mixed plantings due to its powerful anti-weed and anti-wheat effects. In the case of spearmint, it has been shown to have an inhibitory effect on weeds, while wheat has been proven to be resistant. These findings suggest that spearmint has the potential to be integrated into sustainable agriculture and organic farming, although further research is needed in this area. Potential allelochemicals must be defined since they have the potential to deliver new and inexpensive synthetic analogues of natural compounds with improved selectivity, stability, and efficacy for weed and insect control. They should also be toxicity tested on non-target species to ensure their safety. To produce agrochemicals based on natural ingredients, this research must follow a rational path.

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