

## ***Verbesina encelioides*: A Fast Spreading Weed in Semi-arid Regions of North-Western India. Is Climate Change Responsible?**

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### **Abstract**

Alterations in rainfall pattern and rise in temperature along with various anthropogenic disturbances are contributing greatly to biological invasion. In response to ongoing climate change, the sub-tropical and semi-arid regions are shifting towards dry deserts and arid regions, which create a propitious chance for the establishment of highly efficient and opportunistic invasive plant species at the cost of native vegetation. *Verbesina encelioides* is one of such exploitative plants spreading fast in many semi-arid as well as arid regions of the world. Although the presence of *V. encelioides* dates back to 1960s, but its emergence as a dominant invasive weed of dry areas is recent in India. The present study focused on the rapid spread of *V. encelioides* in the north-western states of India owing to its ecological traits as well as changing climate patterns of the country.

*Keywords:* *Verbesina encelioides*; Biological traits; Climate change; Invasive potential.

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### **1. Introduction**

With increased communication and transportation networks across the world, global trading has enormously increased, and consequently enhanced the magnitude of biological invasions during past few decades [1]. Invasive plant species pose a major threat to the biodiversity, affect ecosystem integrity and cause homogenization of the world flora by altering the species composition. Invasive plants reproduce rapidly, spread over large areas of the landscapes and form monocultures of their own [2]. Moreover, the invasive plants can also amend nutrient cycling of the invaded region by changing C:N ratio, eventually leading to negative impact on native vegetation [3]. About 4 % of the total vascular flora of earth has already naturalized new geographical areas, out of which many have the potential to become noxious invaders [4]. Changing climate and global warming have led to a massive change in the floristic composition of the world [5]. Many exotic species of warmer regions are naturalizing the alien areas where they were not reported

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earlier. The ongoing invasion studies suggest that this process is not going to recede anytime soon, as global warming is resulting in the rise of average temperature, and consequently greater vulnerability of the ecosystem towards invasion [6]. Climate change being a plausible reason for the ongoing environmental disturbances is creating more chances for plant invasion in the semi-arid regions of the world. In this context, *Verbesina encelioides*, commonly known as golden crownbeard or wild sunflower, is one such invasive weed that is being favoured by climate change and ecological disturbances. Although the weed was already present in the north-western Indian states before, but a significant upsurge in its establishment has been observed during the time period of 2012-2017. Moreover, perceptible increase in percent cover of *V. encelioides* has also been detected in Punjab, Haryana, Chandigarh and Rajasthan [7,8].

## 2. Materials and Methods

The current study reviewed the published literature for the analysis of the distribution, invasion, ecological as well as the biological traits of the weed *Verbesina encelioides*. For the appraisal of the role of climate change in the fast spread of *V. encelioides* in the north-western regions of India, data were collated regarding two parameters; temperature and rainfall. Reports concerning the average temperature and rainfall of 3 north-western states: Punjab, Haryana and Rajasthan and 1 Union Territory: Chandigarh, were acquired from the database of Indian Meteorological Department for the years 2012-2017. Afterwards, collected data were analysed and correlated with the upsurge in the spread of *V. encelioides*.

## 3. Results and Discussion

*Verbesina encelioides* (Cav.) Benth. and Hook. f. ex A. Gray (family Asteraceae), commonly known as wild sunflower or golden crownbeard, is native to tropical North America. It has been reported to be invasive in various parts of the world, such as Hawaiian island, Midway and Kure Atoll Island, Texas, Oklahoma and Mexico states of USA, parts of Australia, Argentina, Saudi Arabia and South Africa [9]. In Texas, it has been reported to significantly damage the peanut crop due to its high infestations in the agricultural fields [10]. It is now establishing itself as a troublesome weed in various tropical parts of the world including India [11]. In India, it has been reported to occur in the arid and semi-arid parts of Punjab, Haryana and Rajasthan [12,13]. The exact time and purpose of its introduction is not known, however it is assumed to have escaped from the cultivated areas of Rajasthan where it was used for ornamental purposes [14].



Fig. 1. Photographs of *Verbesina encelioides*. **a**) Plant growing in wasteland of semi-arid region of Kotkapura (Faridkot district) Punjab, **b**) thickets of the plant, **c**) head/capitulum with yellow florets, and **d**) mature head with seeds.

*Verbesina encelioides* prefers hot and humid conditions, and after establishment requires very less precipitation. In semi-arid regions of India, particularly in states of Punjab, Haryana and Rajasthan, rising temperature and declining soil fertility have helped this plant to invade rapidly over less adaptive native plants [11,15]. It can be seen growing luxuriantly along highways, railway tracts, open spaces, empty urban plots, abandoned agricultural land and field boundaries [13]. In the north-western India, the plant is fast emerging as a dominant weed, rapidly engulfing the available empty niches of the ecosystem. It is an annual herb (Fig. 1a,b) that generally attains up to ~ 150 cm height. The plant stem has a diameter of  $2.5 \pm 1.0$  cm which is covered with small, dense hair providing greyish-green appearance to the stem. Two patterns of leaf shape and arrangement can be observed in the plant, upper leaves are alternate and lance-shaped, and lower leaves are opposite and triangular. Inflorescence consists of a bright yellow capitulum having numerous disk florets at center surrounded by 10-15 long ray florets (Fig. 1c). A mature plant generally bears around 50-80 flower heads with each having  $35 \pm 10$  seeds (personal observations, Fig. 1d). Therefore, a single plant of *V. encelioides*

can produce about 3000-4000 seeds per year. The seeds are blackish-grey in color with white wings along the margins. Further, the seed dormancy and seedling survival efficiency through unfavourable growth conditions are very high for this plant. Seeds stay viable for 3-4 years even after being buried under the soil [13]. Seed dispersal mostly takes place through wind, air, vehicles or sometimes by birds or insects. As seeds are very light in weight and have wings along their margins, they can easily disperse to long distances. However, some seeds remain concealed under the parent plant and begin to sprout in the next season when conditions become favourable; thereby, dominating the invaded territory for a prolonged time [9]. The plant reproduces only through seed propagation. It exhibits extensive phenotypic plasticity, precocious flowering and high seed production to ensure its survival in the invaded habitats [11]. Under field conditions, it was also observed that *V. encelioides* flowers and produces seeds when it is just about 20-25 cm in height.

*Verbesina encelioides* possesses many attributes such as broad ecological amplitude, habitat variations, phenological diversity, substantial seed production, ability to form monocultures, production of toxic compounds, allelopathic properties and adaptability to extreme climatic conditions, which impart invasiveness to this plant [13]. The plant can grow in a wide range of habitats and soil conditions such as alkaline, sandy, loamy and humus-rich soils with pH range of 7-9, which are usually unfavourable for the growth of other plants [9]. It also lacks natural enemies that may check its fast growth. Some thrips or species of butterflies, which are known to feed on these plants in their native range, do not show any such activity towards plants growing in the invaded zones. It exhibits allelopathy and negatively affects native plants and the agricultural crops [12]. The metabolites released by the weed, especially the phenolic acids, act as growth inhibitors for the native herbs and agricultural plants. Even the water leachates of the toxic weed can bring behavioural changes in the neighbouring plants [16]. The weed expands quickly to other areas by forming impenetrable monoculture colonies, which may pose a serious threat to the native floral diversity. Being poisonous in nature, it is not preferred by cattle when other fodder options are available. However, during drought summer period when there is scarcity of food, the animals may graze upon these plants. As, the toxic plants are only damaging to animals' organ system when they are ingested in high doses [17], same is the case with *V. encelioides*, generally it is not much harmful for the cattle if eaten in less amounts, but if taken in large quantities, it may be fatal. In Australia, massive losses of sheep had occurred due to ingestion of this weed [18]. As far as its uses are concerned, some medicinal uses such as treatment of fever, snake and spider bites, and haemorrhoid and skin problems have been reported in its native range; but in India, local people do not have much knowledge about its potential applications [11].

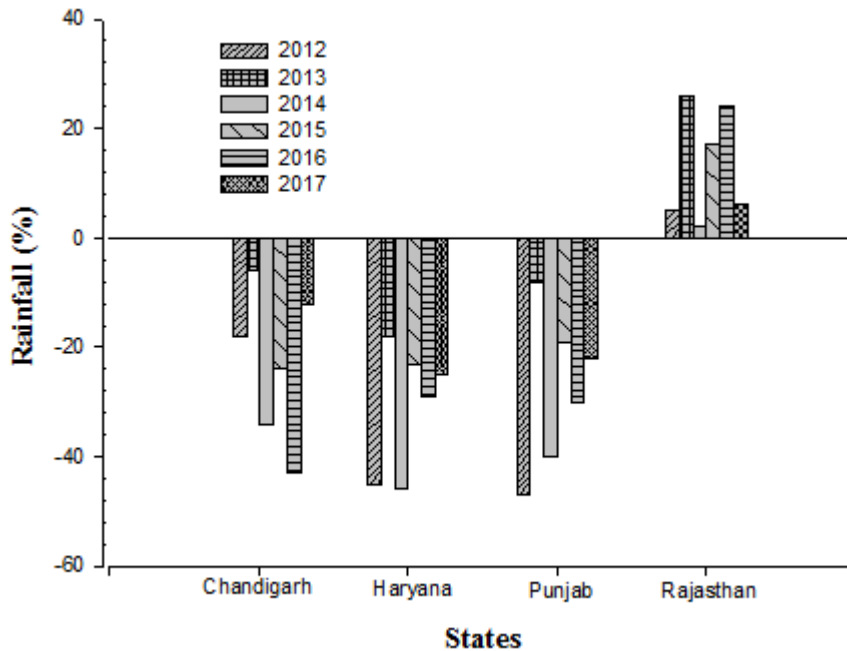


Fig. 2. Rainfall percentage (percentage of actual rainfall with respect to expected annual rainfall) in Northwestern states of India including Chandigarh (source: Meteorological Department of India, [www.imd.gov.in](http://www.imd.gov.in))

A significant rise has been recorded in the percent coverage (nearly 30 %) of *V. encelioides* in the past few years (particularly after 2012), which represents the severity of the weed infestation in the above mentioned states. Moreover, the weed density as well as abundance as depicted by percent cover is higher than ever. As the habitat conditions are crucial for a plant, the temperature and rainfall play primary role in their survival in new environments. *V. encelioides* is known to prosper well in the hot and humid conditions of mean temperature  $35\pm 1$  °C (summer) and  $15\pm 1$  °C (winter) with mean annual precipitation of  $350\pm 50$  mm [14]. North-western Indian territory is experiencing decline in annual rainfall along with rise in mean temperatures (Fig. 2 and Table 1). Consequently, the weed *V. encelioides*, which was earlier limited to a particular habitat, has now rapidly spread throughout the north-western Indian states (Punjab, Haryana, Chandigarh and Rajasthan) [7]. Since temperature and rainfall are two very important attributes of environment [19], the study focused on these two as the plausible reasons for its spread. For this, data on the rainfall and temperature were compiled from the reports of Indian Meteorological Department [20] for the years 2012 to 2017. The rainfall data was expressed as percentage of actual rainfall with respect to expected annual rainfall, whereas temperature data (separately for summer and winter) was expressed as average of the six years (2012-2017). The rainfall pattern for the period 2012–2017 indicated the decreasing

trend in Chandigarh, Punjab and Haryana, whereas an increasing trend was observed in case of Rajasthan (Fig. 2).

Table 1. Mean temperature data of the north-western states of India (IMD).

State	Year	Mean summer temp. (°C)	Mean winter temp. (°C)
Punjab	2012	36	13
	2013	33	14
	2014	35	12
	2015	33	15
	2016	36	15
	2017	34	15
Haryana	2012	33	11
	2013	34	12
	2014	35	13
	2015	34	15
	2016	36	13
	2017	34	15
Rajasthan	2012	35	15
	2013	35	14
	2014	37	15
	2015	36	17
	2016	37	15
	2017	35	18
Chandigarh	2012	31	10
	2013	32	10
	2014	34	11
	2015	31	12
	2016	33	12
	2017	32	18

The average temperature for the said six years was recorded to be ~36 °C in summer and ~14 °C in winter, which showed an increase over the average temperature of the last decade which was ~32 °C for summer and ~10 °C for winter [20]. The decreasing trend of the rainfall and increasing trend of the temperature favour the establishment of *V. encelioides* in these areas since it flourishes well at low annual precipitation and high temperatures. In Rajasthan, where summers are usually very hot, increase in annual precipitation possibly enabled this plant to thrive well in sand dunes also. The trend of deficient rainfall and increasing average temperature in north-western Indian regions has continued for the last two years also (2018-2019) (IMD). Therefore, the climate variations in North-western states in the past few years have been aiding the spread of *V. encelioides* which in turn may affect the species diversity in these states. As *V. encelioides* strongly acknowledges the global warming and other ecological disturbances, it possesses providential chances to invade other Indian states as well.

#### 4. Conclusion

In conclusion, the current study describes the emergence of *V. encelioides* as a new invader in semi-arid regions of the north-western India. As some sub-tropical and semi-arid regions are shifting towards aridity due to rising temperatures and declining precipitation rates, making it difficult for native vegetation to survive in such harsh conditions, and thus paving the way for some adaptable weeds like *V. encelioides* to invade these areas. If *V. encelioides* continues to grow unchecked and unmanaged on an early note, it will have ample impact on the urban, agricultural and natural ecosystems of the country. Considering the present situation, it is of utmost importance that proper effective measures for the prevention of this exotic invasive weed should be taken to control its spread into other states. The study presents some future insights into the establishment of *V. encelioides* as a noxious environmental weed by describing its biological as well as ecological traits. These parameters can be further investigated to provide basis for its prevention and management into other areas that are facing the similar problem of climate change.

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