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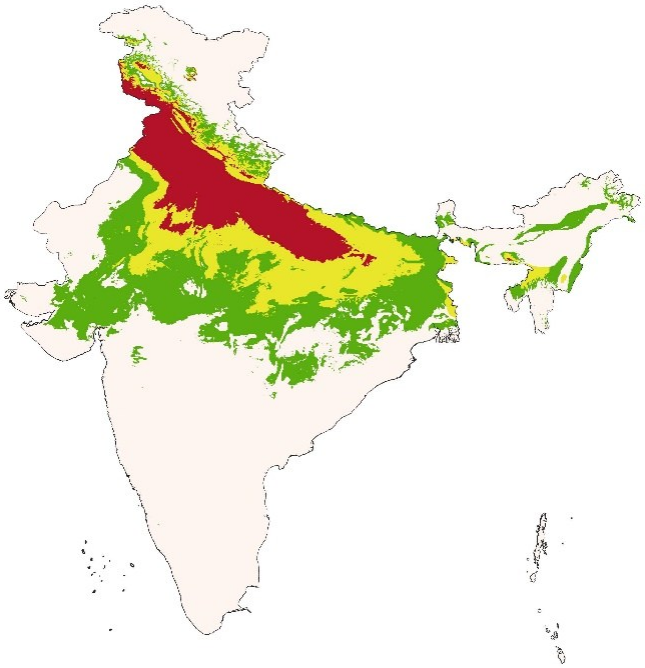
Prediction maps of future distribution of *Phalaris minor* under RCP 4.5 and 8.5 for the year 2050 and 2070



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Introduction

Phalaris minor Retz. is an invasive annual weed native to the Mediterranean region. It has been spread to more than 60 countries of the world, including all the continents except Polar Regions. *P. minor* was reported to be the major weed in Latin America from where it possibly reached India through the imported Mexican wheat during 1964-65, and quickly became problematic by the 1970s after the introduction and large-scale cultivation of Mexican dwarf-wheat. It appears in several winter crops, however, due to its similar morphology and growing requirements, it has become more harmful in wheat than any other crop causing yield losses up to 50% and total crop failure in case of heavy infestations. This invasive weed emerges with the germinating wheat crop, competes for water and nutrients, and in the absence of effective control measures, it can cause huge grain yield losses. Appropriately, it is considered as the most troublesome weed in the wheat mainly in rice–wheat system in Indo-Gangetic plains of India.

Continuous use of isoproturon for the control of *P. minor* in wheat in rice–wheat system for 10-15 years resulted in the development of resistance against this herbicide in the early 1990s. This emerged as the most serious instance of herbicide resistance in the world. This drew the attention of researchers toward formulating the effective management strategies for *P. minor*. However, situation has further deteriorated with the evolution of cross and multiple resistance in *P. minor* against many herbicides. These factors proved it as a major threat to wheat productivity in north-western India. Further, studying the effects of future climate change on distribution of species is one of the fundamentals to manage informative activities for conservation of biodiversity. Therefore, considering the impact of *P. minor* in the wheat, **Prediction maps** were developed for forecasting the invasion potential of this weed in India under current as well as future climatic conditions under Representative Concentration Pathways (RCPs) 4.5 and 8.5 for the years 2050 and 2070 using maximum entropy model (MaxEnt).

Methodology

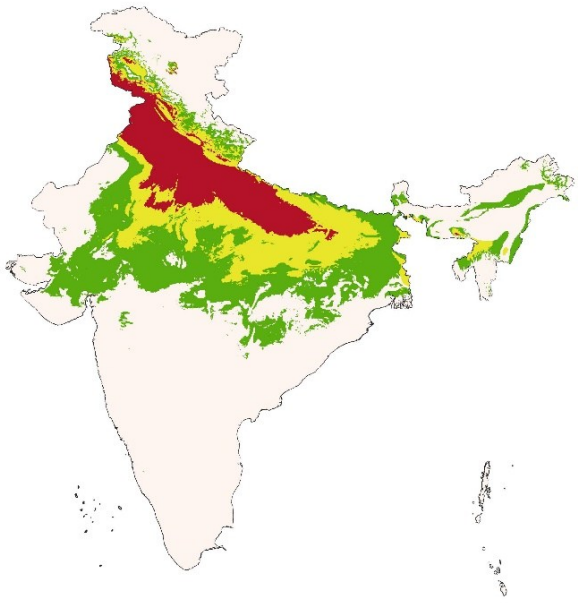
Occurrence data of *P. minor* was retrieved from different sources such as, India Biodiversity Portal; Flora of Peninsular India, Herbarium JCB, Centre for Ecological Sciences, IISc, Bengaluru; GBIF; CABI and from https://www.inaturalist.org/. These records were supplemented with occurrences data collected from the Annual Reports of AICRP on Weed

Management and ICAR- DWR, Weed Atlas, *Vol*. I and II by ICAR-DWR and other published literature. Overlapping occurrence points were removed before analyzing the data. A total of 223 occurrence points were used for model building and validation for the species distribution modelling. The climatic variables with 30 arc seconds (900 m^2) resolution along with elevation data and soil layer were used as input variables for modelling. As future climate data, layers for different RCPs 4.5 and 8.5 at 30 arc seconds for the year 2050 and 2070 were retrieved from Climate Change, Agriculture and Food Security site. For the modelling, cccma_canes2 model developed by Canadian Centre for Climate Modelling and Analysis (CCCma)) was used for future climate prediction. Future climatic data were statistically downscaled data from a Global Circulation Model (GCM) using WorldClim v1.4 as the high resolution baseline 'present' climate.

Out of 19 bioclimatic variables, highly correlated bioclimatic variables were excluded from the analysis, and thus, eight variables along with elevation layer and soil layer were kept for model building and validation. Raster layers of environmental variables were clipped to match the spatial extent of the study region i.e. India. All raster layers of environmental variables were first converted into a uniform projection system i.e. EPSG: 4326 WGS-84 and in 30 arc second spatial resolution (900 m^2) with the help of QGIS v3.22.7. Maps depicting the current geographical distribution and habitat suitability maps of *P. minor* under RCP 4.5 and 8.5 for 2050 and 2070 were obtained using MaxEnt program.

Results

Using the weed occurrence data and environmental variables including elevation and soil layers, current distribution map of *P. minor* was obtained and prepared in four classes of climate suitability i.e. not suitable (0-0.25), low (0.25-0.50), moderately (0.50-0.75) and highly suitable (>0.75) categories. Prediction maps under current and future climatic conditions are given below:



P. minor distribution

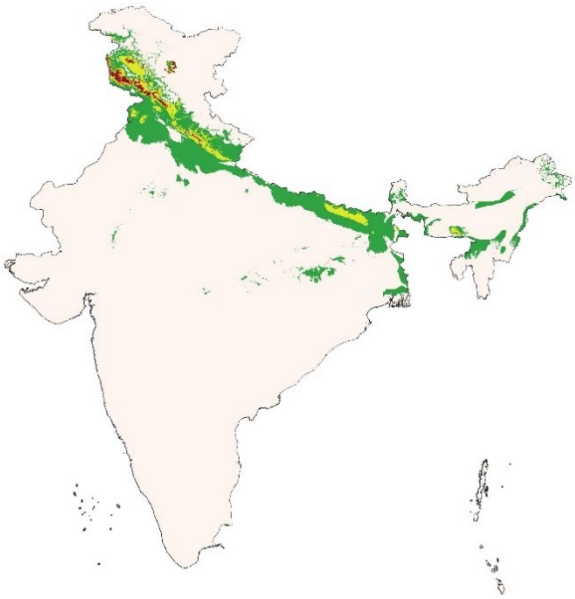
(0-0.25) Not suitable

(0.25-0.50) Low suitable

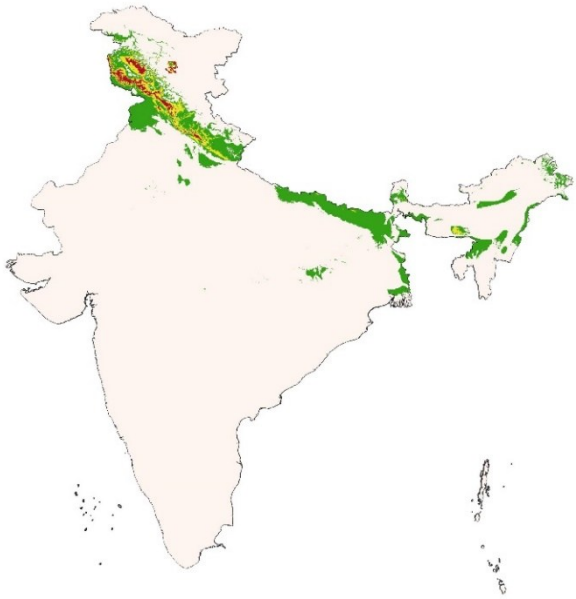
(0.50-0.75) Moderately suitable

(>0.75) Highly suitable

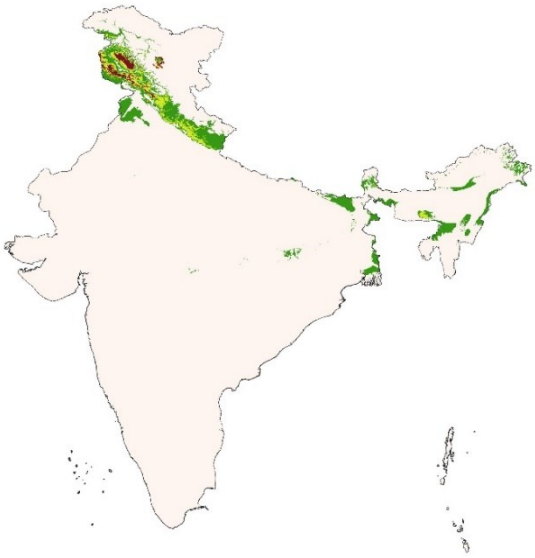
Current



RCP 4.5 2050



RCP 4.5 2070



RCP 8.5 2050

RCP 8.5 2070

Current distribution pattern of P. minor

Prediction maps revealed that out of the total favourable area, modelling classified 1,381,981 km^2 as broadly suitable habitat, with 694,246 km^2 (21.3%) as having low, 390,544 km^2 (11.96%) moderate and 297,191 km^2 (9.10%) highly suitable under current climate. Northern part of India was found to provide an ideal climate for this species in current climatic conditions. Northern states such as Punjab, Haryana, Uttar Pradesh and some parts of Bihar and Rajasthan fall under highly suitable area category. Some parts of Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, Jharkhand, West Bengal and a few areas from North-eastern states i.e., Assam and Meghalaya come under moderately suitable category. However, most of the parts of Madhya Pradesh, Rajasthan, Gujarat, Bihar, Jharkhand, West Bengal, Chhattisgarh, Odisha and a few areas from all North-eastern states fall under low suitable category.

Future distribution pattern of *P. minor*

An overall decrease in climate suitability for this species is found under future climate scenarios for 2050 and 2070 under RCP 4.5 and 8.5. It is observed that invasion hotspots for *P. minor* will be shifted towards the north of the country including few North-eastern parts in all four future climatic scenarios. A significant decrease in areas of suitability is predicted under RCP 8.5 in 2050 and 2070 than RCP 4.5.

It was observed that an increase of 55.7 and 60.1% in unsuitable areas was found in 2050 and 2070 respectively, under RCP 4.5 as compared to current climatic scenario. Moreover, further increase (64.4 and

66.3%) was observed under RCP 8.5 too. This leads to the conclusion that future climatic conditions are not favourable for *P. minor* and may lead to a diminution in species invasiveness and also its shift to newer areas. The range of the suitable areas of invasion is found to be shifted towards the north of the India from the current suitable regions. Our modelling suggests a decline of 96.3% in the range of *P. minor* likely by 2050 under RCP 4.5. Only 10,767 and 14,241 km^2 areas are predicted as highly suitable in 2050 and 2070, respectively under RCP 4.5 as compared to the current climatic conditions (297,191 km2). Same trend was observed in time periods 2050 and 2070 under high-emission scenario (RCP 8.5).

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Table. Climatically suitable areas (in km^2) for *Phalaris minor* under current and future climate scenarios

Range	**Class name**	**Current** (in km^2)	**RCP 4.5**		**RCP 8.5**	
			2050 (in km^2)	**2070** (in km^2)	**2050** (in km^2)	**2070** (in km^2)
0-0.25	Not suitable	1,882,984	2,931,441 (55.7%)	3,013,677 (60.1%)	3,095,580 (64.4%)	3,132,210 (66.3%)
0.25-0.50	Low suitable	694,246	271,349 (-60.9%)	197,797 (-71.5%)	121,940 (-82.4%)	94,813 (-86.3%)
0.50-0.75	Moderately suitable	390,544	48,779 (-87.5%)	36,622 (-90.6%)	32,367 (-91.7%)	26,443 (-93.2%)
>0.75	Highly suitable	297,191	10,767 (-96.3%)	14,241 (-95.2%)	12,450 (-95.8%)	11,274 (-96.2%)

Benefits of the Product

- This information will be useful to know the potential distribution of *P. minor* in current as well as in future climate.
- This information will help in assessing the risk as well as planning of appropriate long-term management strategies for the management of *P. minor* resulting in yield and productivity gain in the associated crops.
- Using the prediction maps, weed control strategies may be focused to those areas where the climatic conditions are highly favourable for *P. minor* invasion which ultimately will save time and energy on weed management.

Upscaling of the technology:

(i) These maps are first of their kind in describing the invasion potential of alien invasive weed *P. minor* under climate change scenarios which is a current threat to rice-wheat system in Indo-Gangetic plains of India.

(ii) Prediction maps provide information about the current and future invasion potential of *P. minor* in India under climate change by 2050 and 2070 under two scenarios i.e. RCPs 4.5 and 8.5.

(iii) It provides information on **substantial environmental factors** affecting the potential distribution of species and help in predicting the infestation potential of species in new areas.

(iv) This will be **helpful in assessing niche dynamics** of alien invasive weed *P. minor* in India under projected climate change scenarios.

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For more information contact

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