PREDICTION OF CLIMATICALLY SUITABLE AREAS FOR THE GROWTH AND REPRODUCTION OF NODDING THISTLE

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Nodding thistle (*Carduus nutans*), is continuing to spread, particularly on tableland pastoral areas of New South Wales. A model combining a growth index and phenology/heat sum model interfaced with a soil water model was developed for predicting the limits of climatically suitable areas for the growth and reproduction of the thistle.

Weekly mean climatic data of radiation, ambient temperature, rainfall and pan evaporation for 286 stations throughout Australia were analysed to predict the relative suitability of different areas by simulating the growth, development and seed yield of the thistle. The thistle was modelled as a two phase system. The first was the growth phase involving leaf development and floral initiation and the second was flowering and grain filling. In the first phase the growth rate of above-ground dry matter was assumed to be proportional to the biomass of the system using a sigmoidal growth function to limit the ultimate size of biomass, using the equation:-

$$\frac{dW}{dt} = K_1 W$$

where: - $K_1 = K_2 (W_{max} - W)$

- K_1 is a growth constant
- W_{max} is the limit to which biomass can develop
- K_2 is predicted using the growth index of Fitzpatrick and Nix (1970)

Growth of above-ground biomass was predicted for the first growth phase. The size of W at the end of this stage set the potential yield of the thistle crop in purely arbitary units.

The length of the two phases was controlled by an experimentally derived phenological stage/heat sum model (Medd 1975). It is known that nodding thistle has a qualitative cold temperature vernalization requirement for floral initiation. A relationship between prevernalization heat sum (PVHS) and vernalization degree sum (VDS) was developed where:-

$$PVHS = \frac{(\text{max.} + \text{min. ambient temp.})}{2}$$ - accumulated daily for the period from germination until minimum ambient temperature was $\leq 11^{o}C$.

$$VDS = (11 - \text{min. ambient temp.})$$ - accumulated daily for the period when min. ambient temp. was $< 11^{o}C$.

Fulfilment of this relationship, resulting in floral initiation, thus marked the end of the first phase. The heat sum at the end of phase one (HSI) was determined by the equation:-

$$HSI = 1421 + 1166\ PVHS$$

Stations unable to accumulate sufficient PVHS and VDS, and therefore unsuitable for nodding thistle development, were predicted by the model.

For stations where development proceeded, phase two was terminated when the total heat sum (THS) = HSI + 1200.

Final yield calculated at the end of phase two (expressed as a relative, not an absolute, value) was predicted by depressing the potential yield according to a soil moisture stress index (Nix and Fitzpatrick 1969). This procedure was repeated for all stations which were then ranked. Ranking was determined according to whether the thistle required 1 or 2 years to complete its life cycle in relation to germinating date, together with relative yield estimates for individual stations.

RESULTS

Areas predicted with climate suitable for the growth of nodding thistle, both as an annual and biennial, embraced all areas in which the thistle has been recorded, namely Tasmania, south eastern Victoria and the Southern, Central and Northern Tablelands of New South Wales. Several areas in which the thistle has not yet been recorded were predicted as potentially suitable by the model. These included the Eastern Downs of Queensland, south western Victoria, Adelaide Hills in South Australia and south western Western Australia. The model also predicted that the species could grow as a biennial on the coastal areas of New South Wales and southern Queensland, although it is considered that these coastal areas have only marginal suitability for the growth of the species.