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Mitigating dry season food insecurity in the sub-tropics by prospecting drought-tolerant, nitrogen-fixing weeds

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LI-BIRD

Abstract

More than 600 million smallholders suffer seasonal poverty and food insecurity in the dry season **(Vaitla *et al.*, 2009)**. Agricultural terraces are typically fallow in the dry season, low soil moisture inhibits the growth of most crops **(Grace *et al.*, 2012)**. Fallow terraces are particularly vulnerable to soil erosion and loss of fertility at the onset of the rainy season, this leads to an increased weed pressure and in turn exacerbates female drudgery **(Gardner & Gerrard, 2003)**.There is a global need for drought tolerant legume crops that provide food and feed in the lean season **(El-Beltagy & Madkour, 2012)**. Stress tolerant crops can be improvement and development with wild plants **(Dempewolf *et al.*, 2014)**. Legume productivity in the dry season benefits from improved water use efficiency and biological nitrogen fixation in dry soils **(Bunch, 2012).**

An ethnobotanical survey was conducted in mid-hills of Nepal to identify genetic resources of dry-season legumes. An automated irrigation system was developed to precisely water potted plants and facilitate screening candidates for traits conferring drought tolerance in the greenhouse.

Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Reference
Dry season				Monsoon						Dry season		
Wheat				Wheat or finger millet						Wheat		Pariyar (2008)
Fallow				Wheat or finger millet								Pariyar (2008)
Mustard		Fallow	Maize and soybean						Mustard			Pariyar (2008)
Fallow			Maize or upland rice						Fallow			Pariyar (2008)
Wheat			Wheat or rice						Wheat			Pariyar (2008)
Barley			Maize					Fallow		Barley		Pariyar (2008)
Wheat		Fallow		Rice and soybean on bunds						Fallow	Barley	Rachie and Bharati (1985)
Barley			Maize and soybean						Fallow	Wheat		Rachie and Bharati (1985)
Wheat		Fallow	Rice and black gram on bunds						Fallow		Barley	Rachie and Bharati (1985)
Fallow						Black gram			Fallow	Wheat		Rachie and Bharati (1985)
Wheat		Fallow	Rice and horse gram on bunds						Fallow		Barley	Rachie and Bharati (1985)
Barley		Fallow	Maize and horse gram						Fallow	Wheat		Rachie and Bharati (1985)
Wheat			Rice and ricebean on bunds							Fallow	Barley	Rachie and Bharati (1985)
Barley		Fallow	Maize and ricebean					Fallow		Wheat		Rachie and Bharati (1985)
Peas		Fallow		rice					Fallow		Barley	Rachie and Bharati (1985)
Fallow		Maize				Fallow		Pea and mustard				Rachie and Bharati (1985)
Potato			Maize and ricebean							Potato		This study
Common bean				Maize						Common bean		This study
Lentil					Maize					Lentil		This study
Faba bean			Fallow	Maize						Faba bean		This study

Figure 1: A compilation of crop calendars for the mid-hills of Nepal **(Small and Raizada, unpublished)**

Objectives

1) Identify candidate legume species in Nepal.
2) Characterize candidates in the greenhouse under water deficient and water sufficient conditions.
3) Evaluate the effect of drought stress on yield, water use efficiency, and nitrogen fixation.

Methods: Flow chart

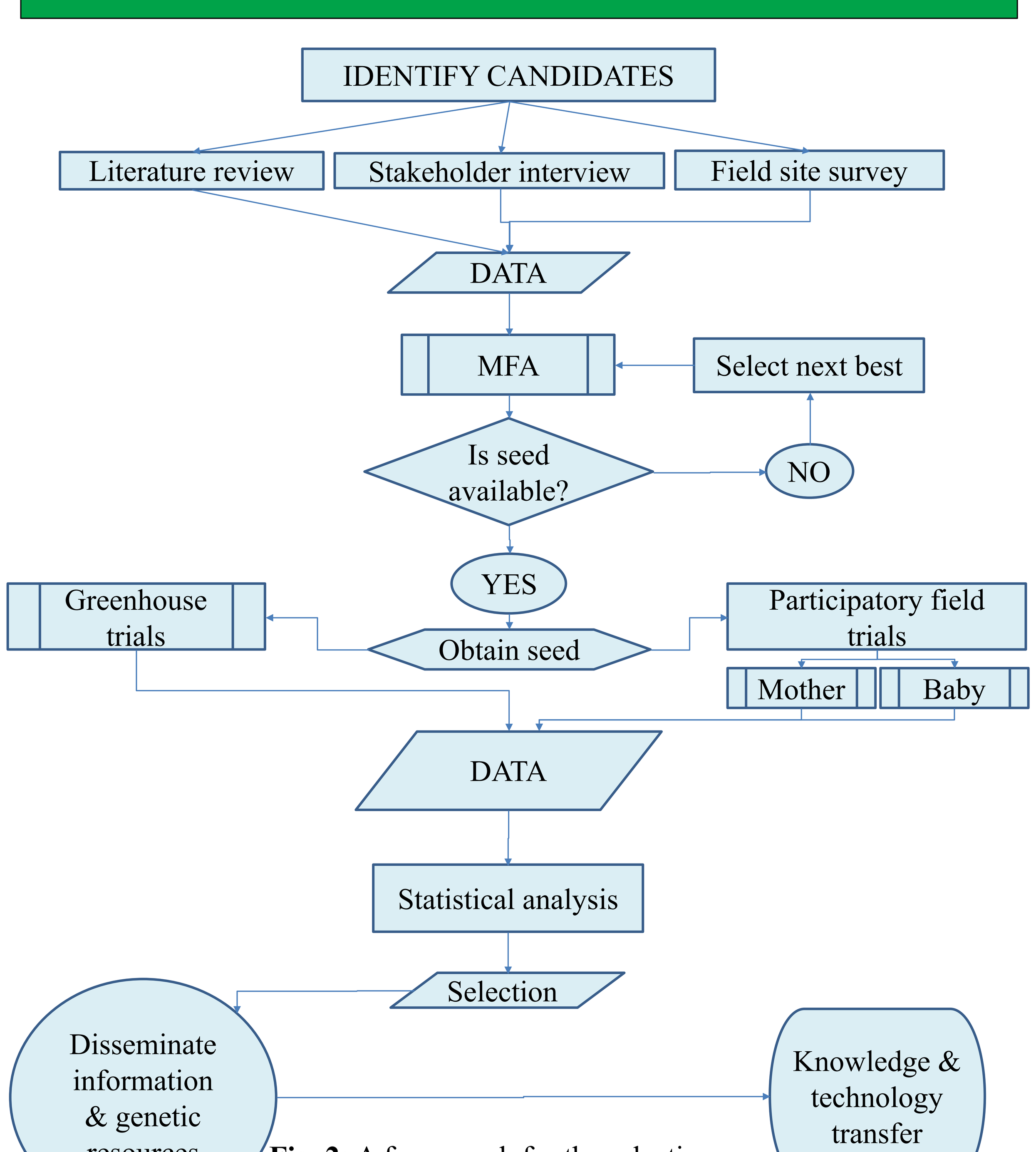
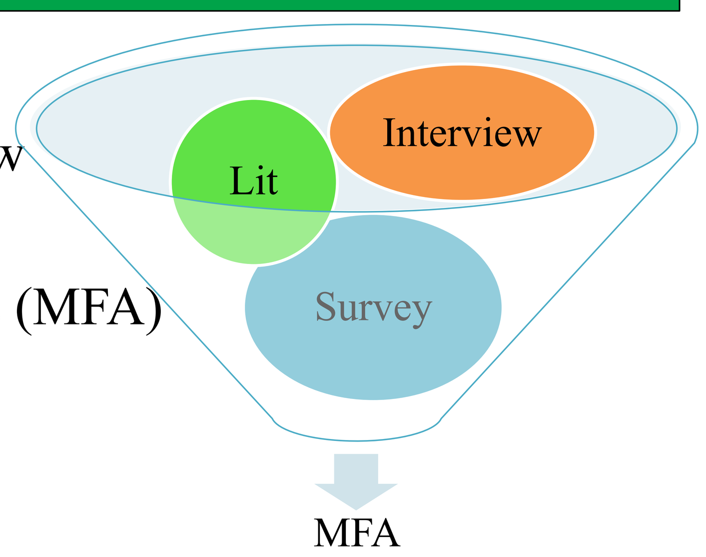


Fig. 2: A framework for the selection of dry season weeds

Methods: identification of candidate legumes

- Literature review
- Stakeholder interview
- Field site visits.
- Multi-factor analysis (MFA)



Results: Nepal as a case study

78 candidate leguminous weeds and underutilized crop species were identified as candidates. The most promising of the candidates were identified in the genera: *Cajanus, Lablab, Lens, Lathyrus, Vicia, Medicago, Trigonella, and Pisum.* Lentil (*Lens spp.*) was selected for further characterization.

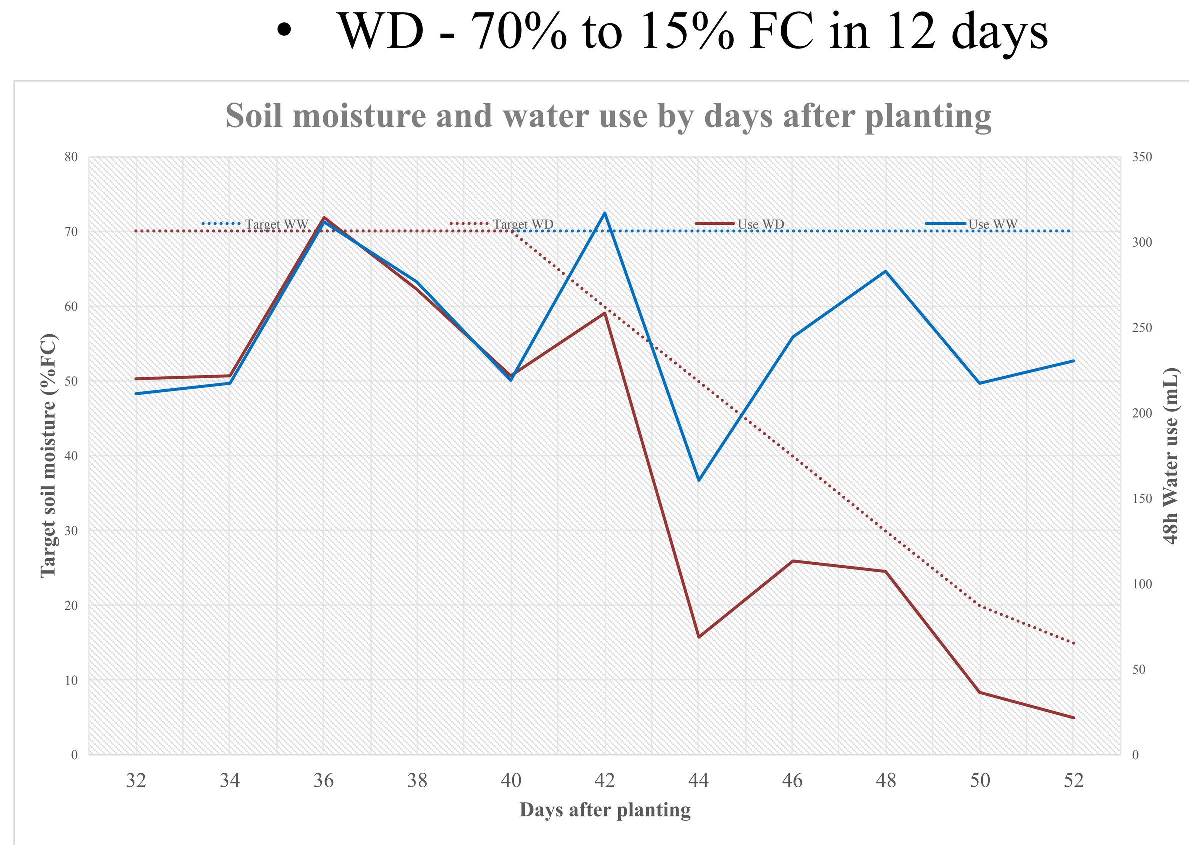
Methods: Characterization

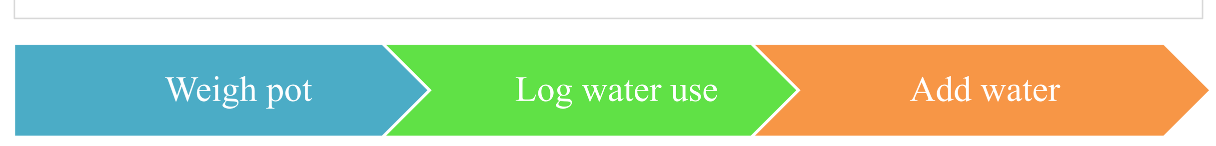
Materials

- Greenhouse with HPS and MH lighting
- Media: 2 PGX:1 B Sand
- Fertility: 1g 20-20-20 + micronutrients per pot
- Lysimiter based on Arduino Nano see github.com/Hiiek/nanoLysimiter
- Candidate *Lens spp.* Canada (4), Nepal (7)

Methods

- Irrigate plants on a mass balance basis every 48h
- Maintain 70% FC until 40 d
- Initiate treatments after 40 d
  - WW – maintain 70% FC
  - WD - 70% to 15% FC in 12 days



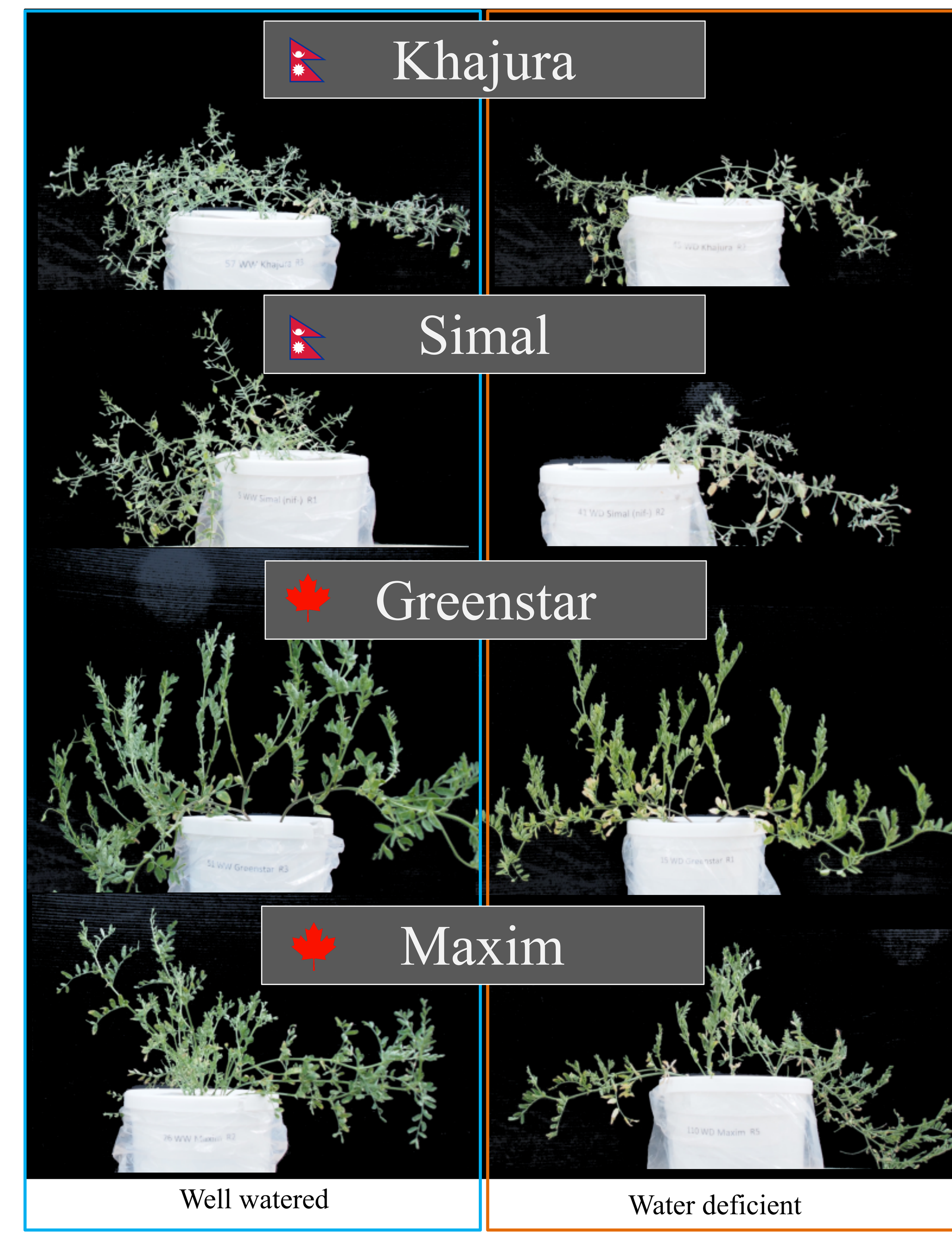


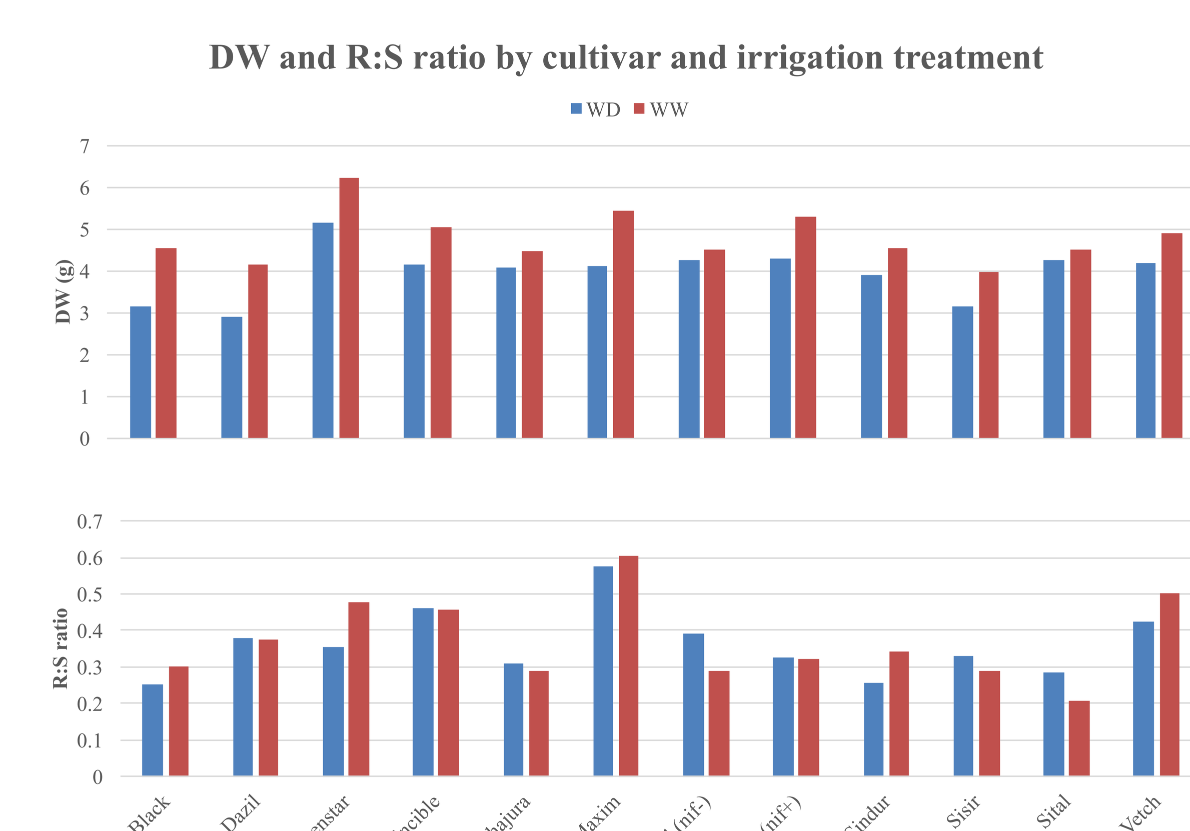
- Measurements
  - Whole plant water use efficiency
    - yield/water use **(Earl, 2003)**
  - Nitrogen fixation
    - N14/15 **(Unkovich *et al.*, 2008)**
    - *GlnLux* **(Tessaro *et al.*, 2011)**
  - Root architechture
    - WinRhizo **(Shiotsu *et al.*, 2014)**
  - Shoot length, number of branches
  - Tissue specific fresh and dry weights
  - Seed pod and nodule count
  - Stomata density & morphology
- Relative measures compare WW to WD treatment
  - R:WUE, R:T, R:BNF

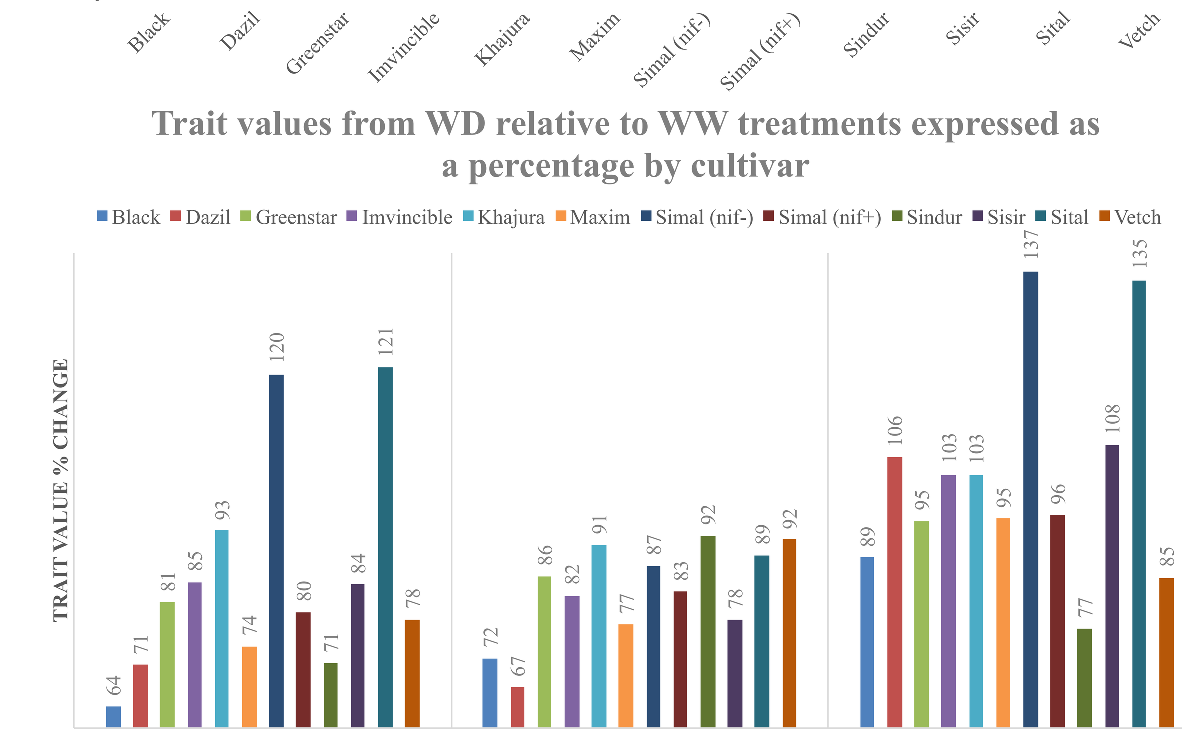
Preliminary results

Preliminary results indicate differences between cultivars for the traits of interest

- Change in trait value from WW to WD
  - Large difference in R:S for Simal (nif-) and Sital
- Variation in biomass yield between cultivars and treatments







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