Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

Should the gravel content of soils impact on your management decisions?

Bill Bowden, West Midlands Group

22 February 2014

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

The Project Specifications

- A survey and desktop study funded by COGGO.
  - To review how the gravel content of soil affects management decisions.
  - To suggest changes to current input management decision making to take account of the gravel content of soils.

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

Findings from the survey

- Most of the surveyed farmers, growers, advisers agronomists and various specialists thought that the role of gravel was well worth investigating.
- However **the management of gravelly soils** was of more interest **than the impact of the gravel content** on management decision making and advice.

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

Findings from the desk top study

- WA fertiliser recommendation systems adjust down the nutrient supply for gravel content and this leads to increased fertiliser requirements.
- Accounting for gravel content reduces the tonnage of lime recommended.
- The gravel content of soils is rarely sampled for, or estimated, correctly.

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

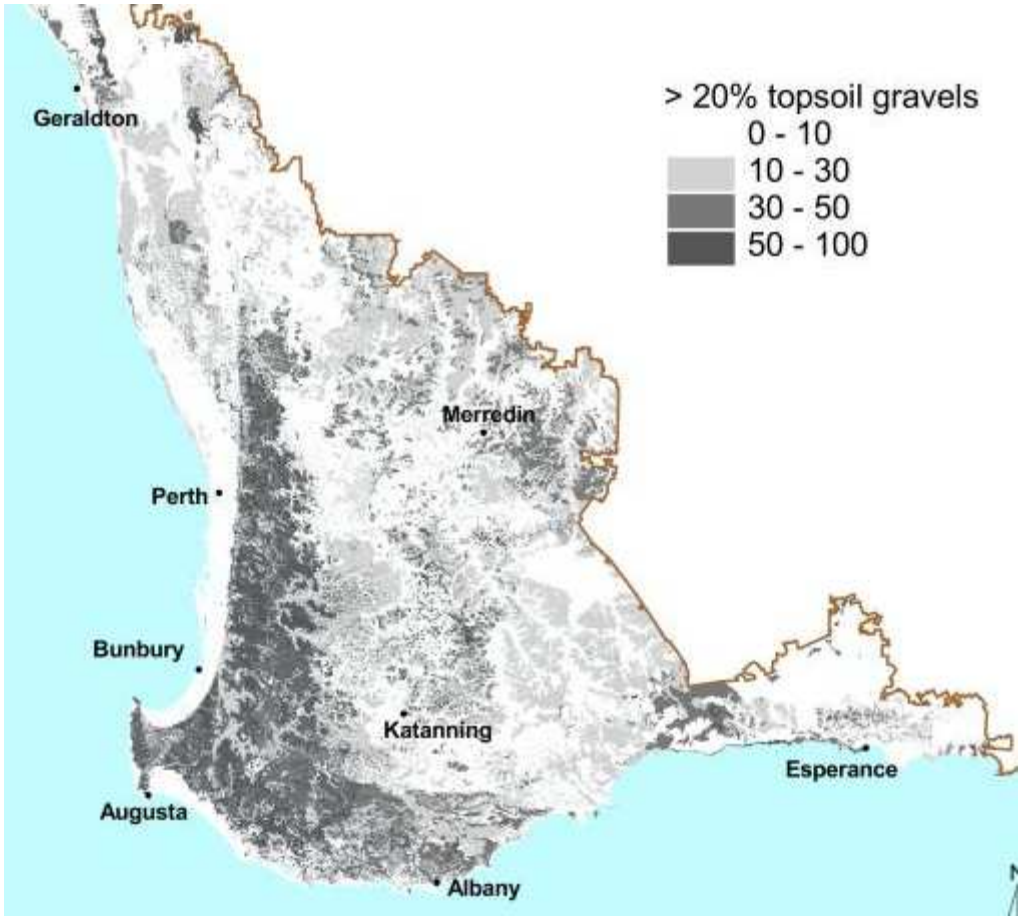
GRDC Grains Research & Development Corporation
Your GRDC working with you

Why study the effect of gravel content?

- **If a soil contains 50% inert gravel then:**
  - The supply of nutrients in a given depth would be halved
  - Half the rate of fertiliser would give the same concentration
  - Lime rates could be halved to raise pH by one unit
  - At a given OC%, carbon sequestration would be halved
  - The soil would store half as much water.
  - Water would drain more readily and leach more chemicals
  - There would be half the PBI and CEC to hold nutrients
- **Is gravel content handled correctly? What are the facts?**

CROP updates

Distribution map of percentages of soils with >20% gravel in the surface (thanks Dennis van Gool).

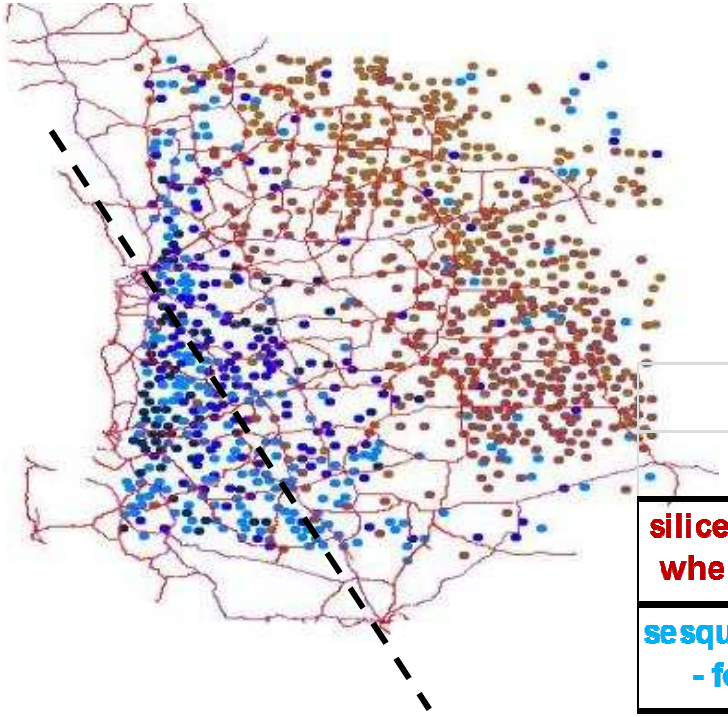


Back to basics - what are gravels?

- Gravels are soil mineral particles which do not pass a 2 mm screen
- They range from inert (rock) to reactive (hard mottles) to water and chemicals.
- In WA gravels are mainly lateritic and fall into two main classes.

Distribution of laterite geochemical types in the SW

(thanks Ted Griffin and Bill Verboom)



Wodjil /Tamma laterites

Jarrah forest laterites

	SiO2 %	TiO2 %	Al2O3 %	Fe2O3 %
siliceous - wheatbelt	54	0.56	20	16
sesquioxide - forest	25	1.09	40	22

CROP updates

Buckshot gravel concretions
(sesquioxide rich – inert?)

Hardened mottles
(silica rich – reactive?)

Surface appearances can be deceiving

90% surface cover is probably less than 25% gravel content

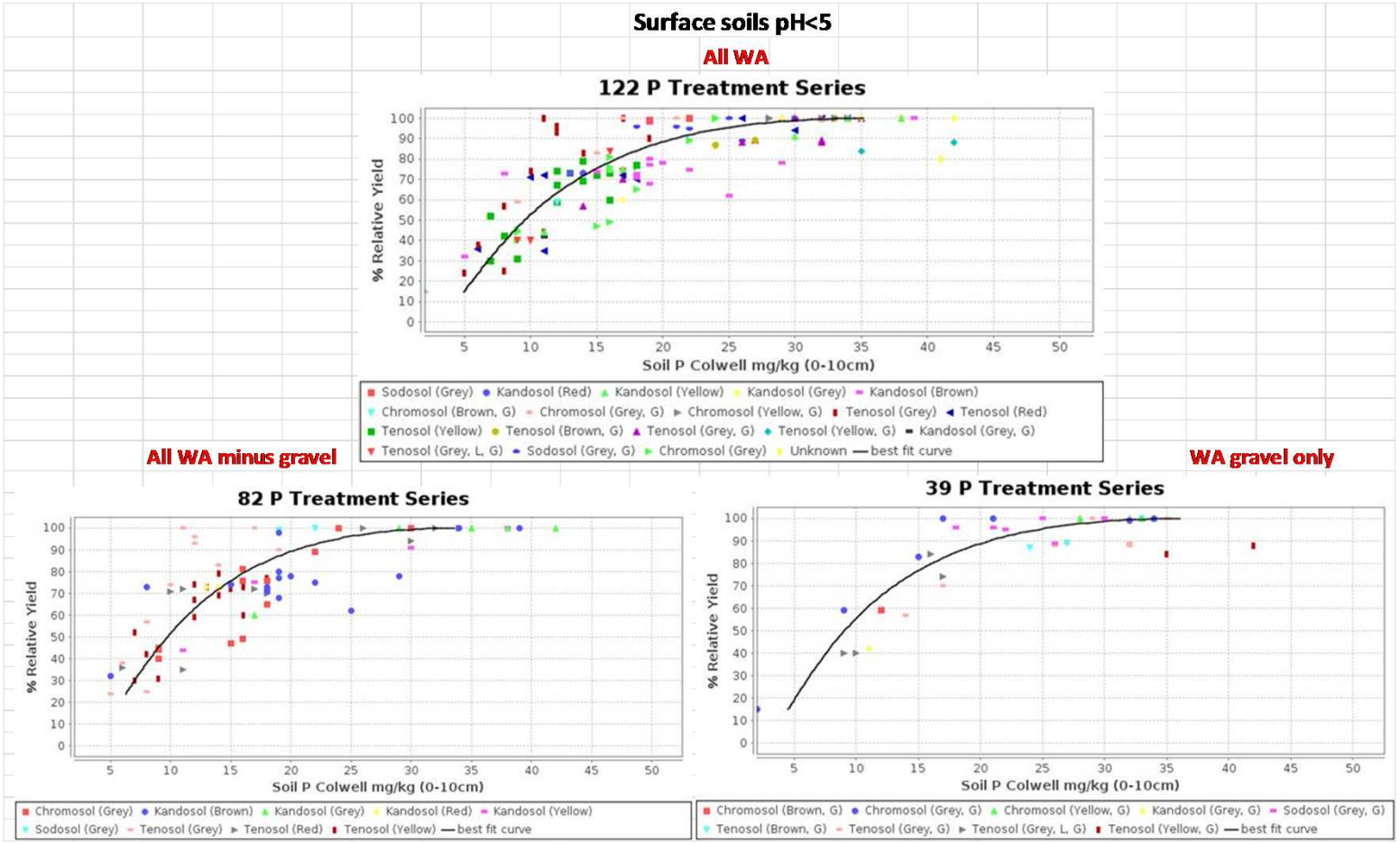
Gravel content and recommendation systems

- **Although rarely measured correctly, gv% is estimated and used in the following recommendation systems**
  - Fertilisers
  - Lime
  - Carbon storage
  - Profile water contents
- **It is not used for herbicide and pesticide recommendations**

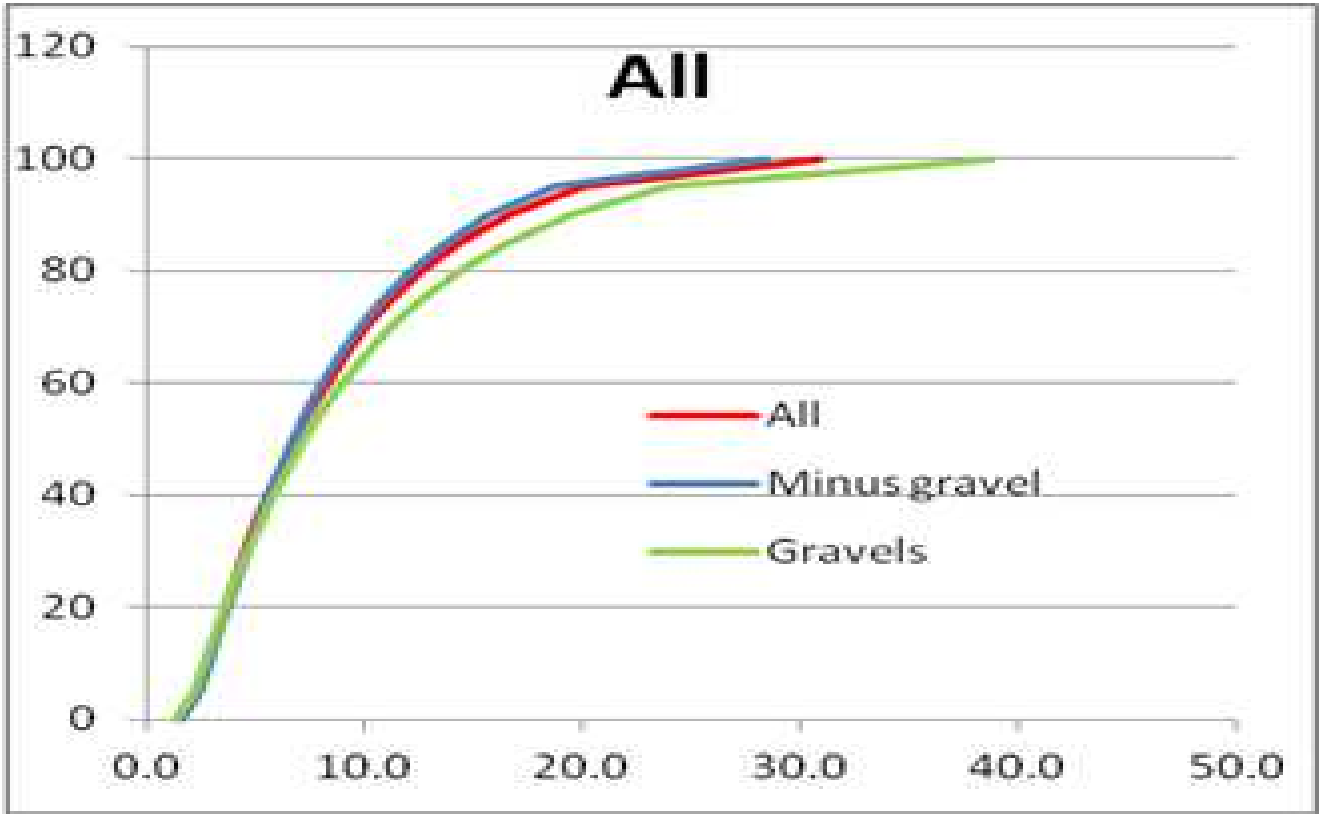
Fertiliser recommendation systems

- **Soil testing uses analyses of the fines to estimate available soil nutrients.**
  - These analyses are used to develop **soil test calibration curves**.
  - Sometimes these soil test results are adjusted downwards according to gravel content
  - This would be wrong unless there is supporting data and theory to back the reduction.
  - The net effect is that fertiliser recommendations would rise.

Calibration curves for wheat responses to soil P in WA



Fitted P soil test calibration curves from the BFDC data base



Adjust for inert gravel content?

- Separate calibration curves into gravel and non-gravel soils?
  - Now it is possible and easy using the BFDC data base
- Reduce supply using a multiplier of (1-gv%/100)?
  - Used for NPK (and S?) but is it appropriate?
- For some nutrients, there should be increased fertiliser use efficiency because gravel increases the average concentration of an applied rate?

Fertiliser recommendation systems not directly relying on soil test calibration curves

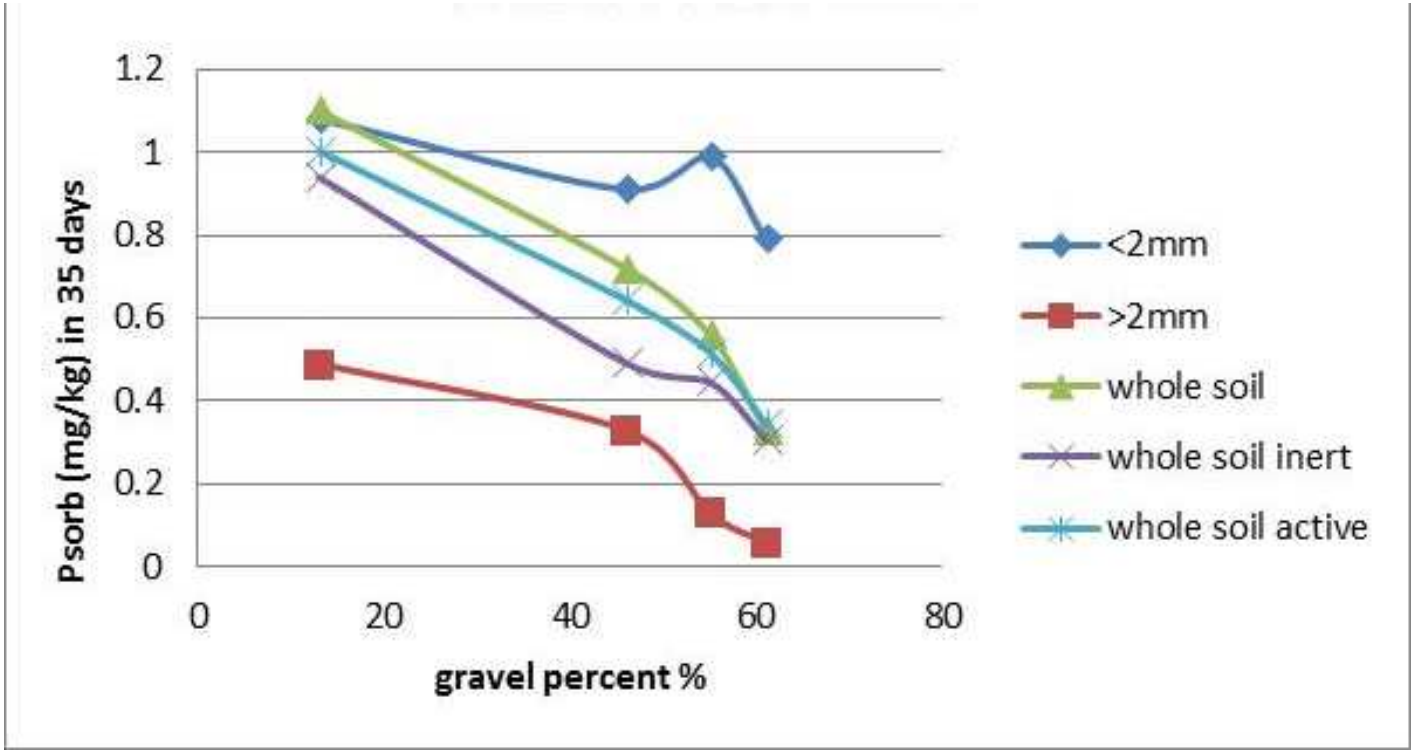
- **Fertiliser required = (crop demand – nutrient supply)**
  - These (eg nitrogen and/or non-economic) systems usually convert the soil test analyses to kg/ha of available nutrient.
  - this should be done on a **whole soil basis** using depth, bulk density and gravel percentage.
  - Gravel contents (and to a lesser extent, BD) are often **ignored** in such calculations.
  - In such cases, the nutrient supply will be over estimated and fertiliser recommendations would be lower

Other implications of inert gravel content

- Inert gravel content should induce more leaching
  - Surface puddling on gravel soils could cause more infiltration and more leaching
  - Some gravels hold available water and reduce leaching.
  - Preferred pathways for water flow around gravel could also reduce leaching of nutrients
- Nutrient buffering should be reduced by inert gravel
  - CEC for cation buffering
  - pHBC for lime and acidification buffering effects
  - PBI or P buffering – eg Weaver et al

Weaver et al 1992. Effect of gravel on P sorption

Note that here the forest gravel is not inert



Gravel content on % reduction of P required for maximum growth of clover and wheat – Weaver et al

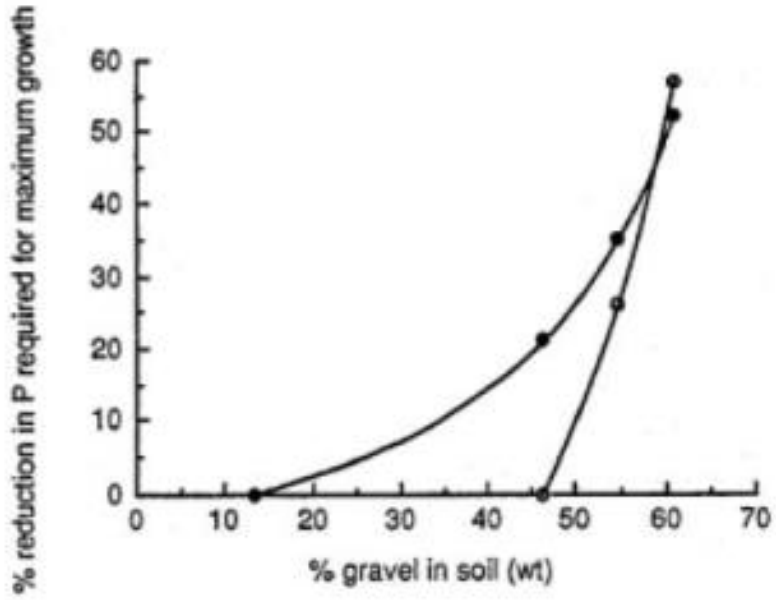


Fig. 5. Estimated reduction in P required for maximum growth of clover (●) and wheat (○) on Yalanbee soil at different soil gravel contents.

Gravel content and liming

- **Liming and acidification – gravel reduces the pHBC**
  - Gravel reduces the amount of soil to be limed in a given layer
  - Less lime should (and is) recommended for gravel soils.
  - For the same inputs, liming (and acidifying) effects should move deeper, faster

Gravel content and carbon sequestration

- Carbon (t/ha) must be calculated on a whole soil basis.
- The OC% of fines must be adjusted by (1-gv%/100), BD and depth
- BD and gravel % are often poorly estimated

Gravel content on herbicide and pesticide use?

- Herbicide and pesticide recommendations may be altered for gravelly soils but not for the gv% of soils
  - Effectiveness is not sensitive to rate of application?
  - The gravel absorbs liquid sprays?
  - Granular pesticIde concentrations increase with gv%
  - Leaching of soil mobile pesticides may increase with gravel content

The management of gravelly soils and you?

- Best soils? Worst soils?
- Better pasture establishment
- Correlate with soil potassium?
- Correlates with clay at depth? +ve/-ve?
- Worst weed problems? Ecology
- Cultivation depth?
- Machinery wear?
- Extreme non wetting?
- Load bearing

Three key messages

- 1. The gravel content of soils (gv%) affects many soil processes which impact on input decision making but it is rarely sampled or estimated correctly.
- 2. In some situations gv% is used quantitatively where it is not justified and in other circumstances it is ignored where it should be used.
- 3. More resources and work needs to be put into answering the questions raised in this study.

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

Acknowledgements

- COGGO for funding the project
- The West Midlands group for sponsoring it
- The many colleagues who answered the survey and have given valuable advice and feedback
- Wayne Pluske and Doug Sawkins for encouragement and review

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

Questions?

bbowden@agric.wa.gov.au

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

- Supplementary slides for possible questions are attached below but can be wiped out for brevity

CROP updates

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

Gravel content and soil water relations

- Storage
- Drainage
- Pawc
- Run-off
- Infiltration
- Mulch –

CROP updates

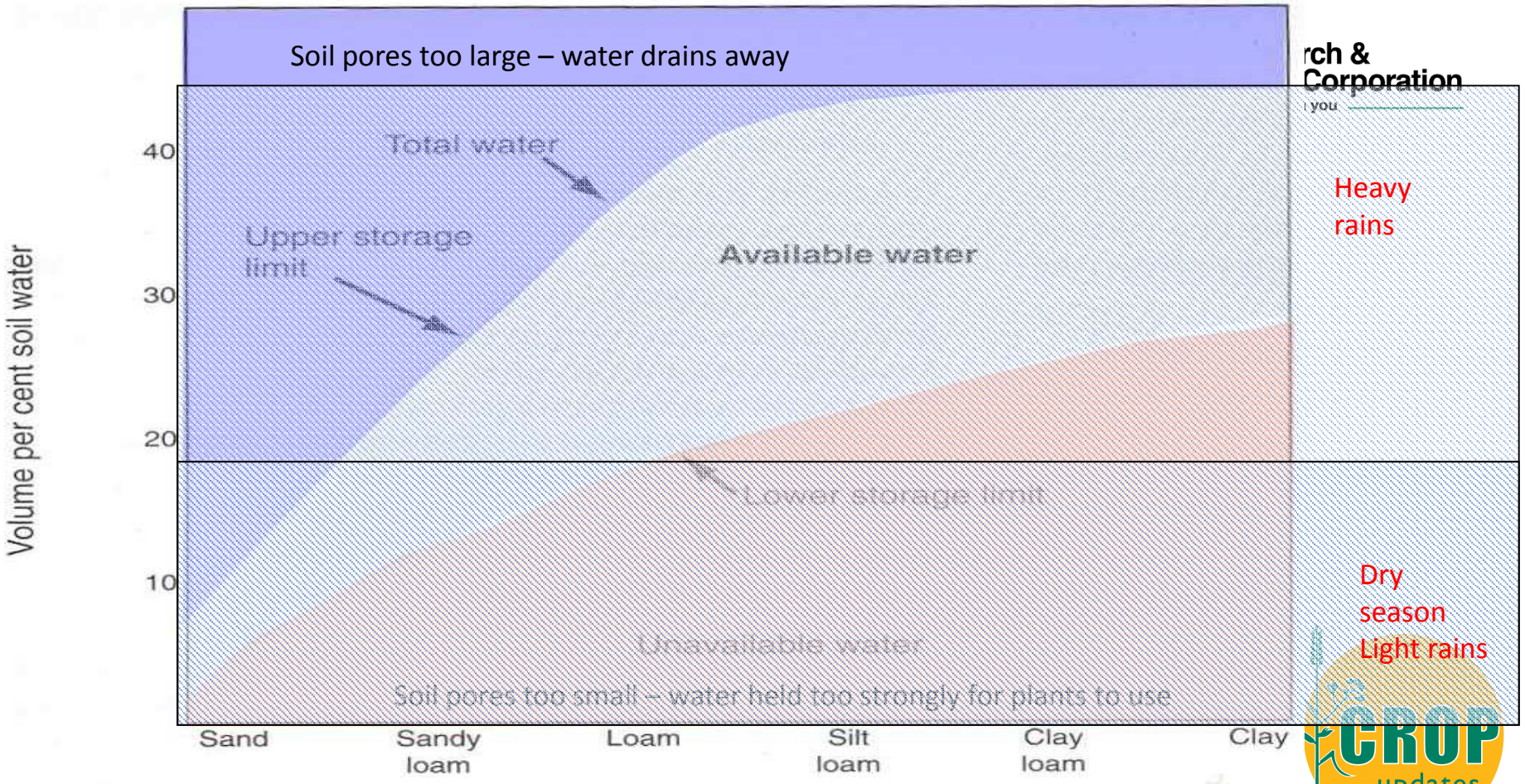


Figure 3.3.1 *The relative amounts of water available and unavailable for plant growth in soils with textures from sand to clay (from Kramer 1983).*

Department of Agriculture and Food

What is:

- ***Drained Upper Limit (DUL)***

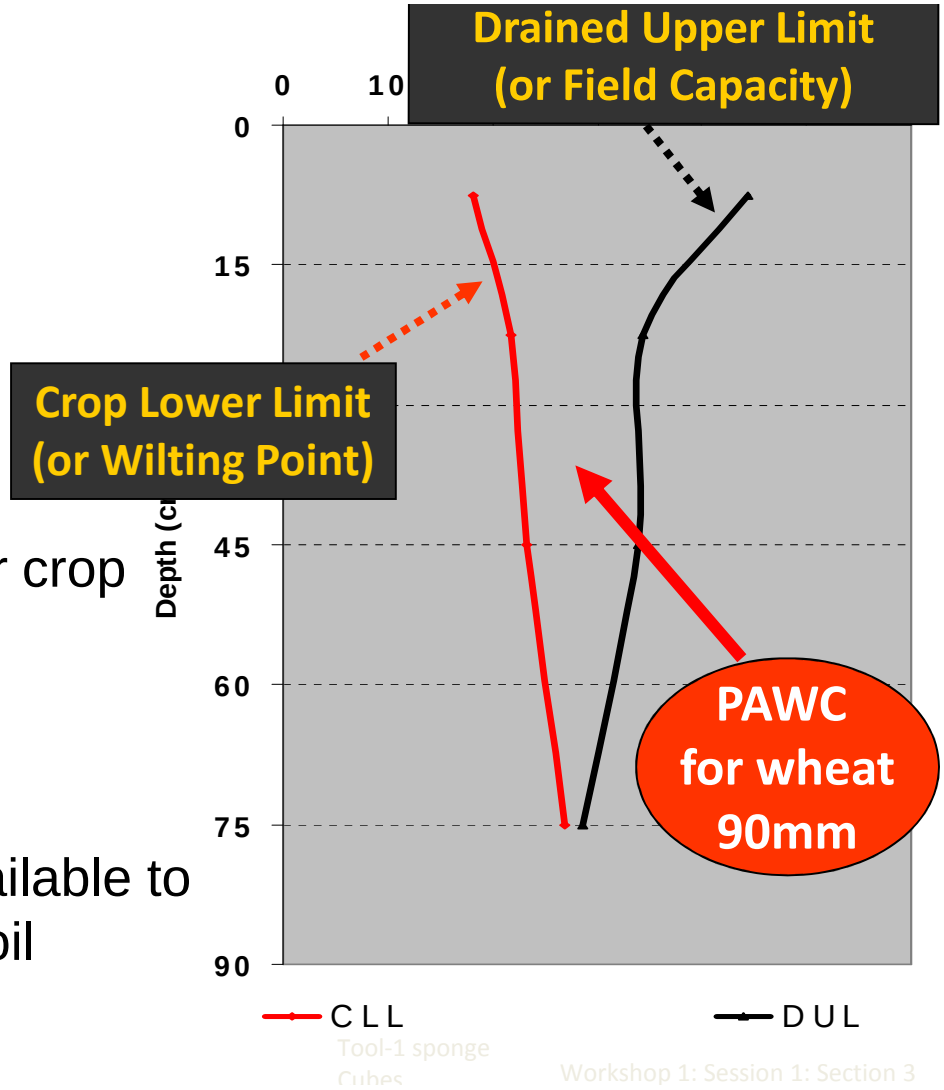
Amount of water able to be held in a soil after drainage has ceased

- ***Crop Lower Limit (CLL)***

Limit of water extraction of a particular crop on a particular soil

- ***Plant Available Water Capacity (PAWC)***

Maximum amount of water available to a crop grown on a particular soil

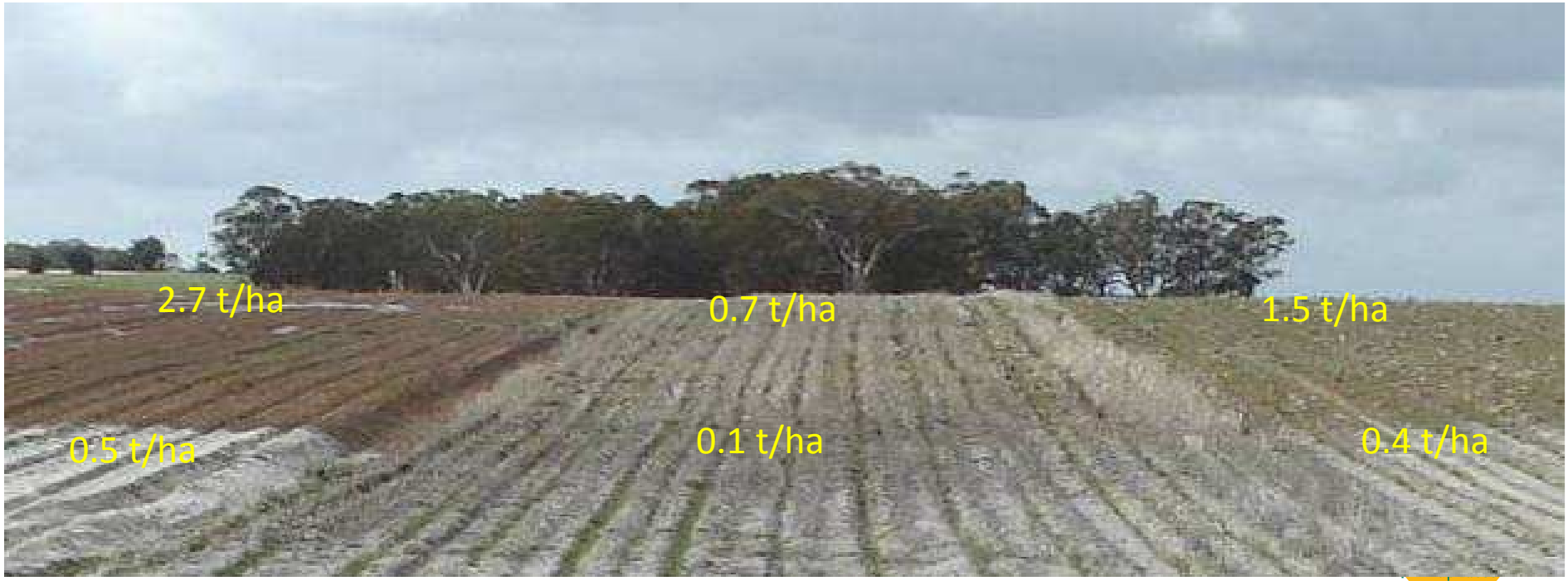


Other effects of gravels in soils?

- Gravels are load bearing
- They can reduce wind and water erosion
- Increase or decrease soil water storage.
- They can increase the germination of pastures
- Concentrate root growth
- By causing ponding they can improve infiltration.
- Low sorptivities of gravel can cause more run off
- Gravels can serve as surface mulches

Gravel as a mulch? Syme, Bolgart 13 July 2010

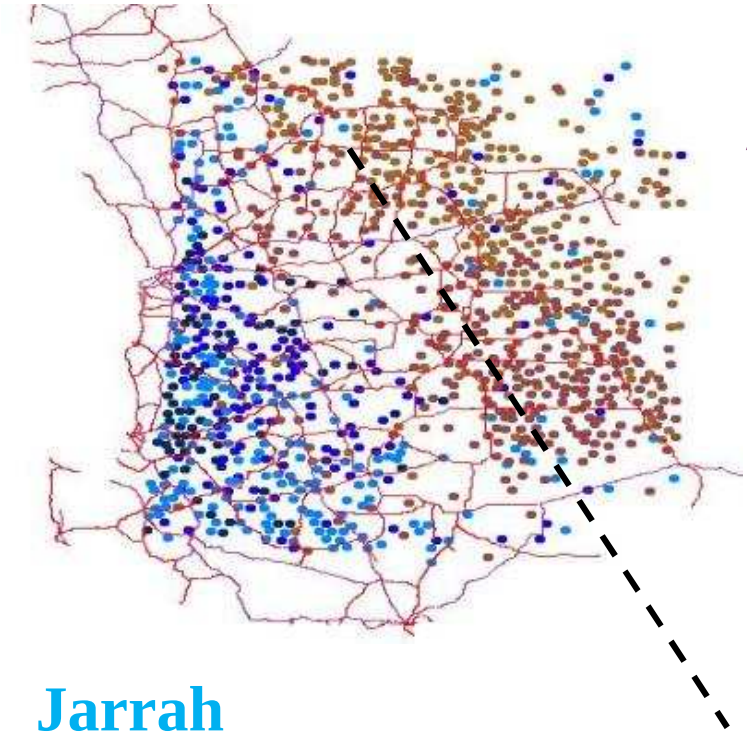
< mouldboard (no weeds), control (very weedy), spader (weedy)>
establishment



Yield components responses to cultivation

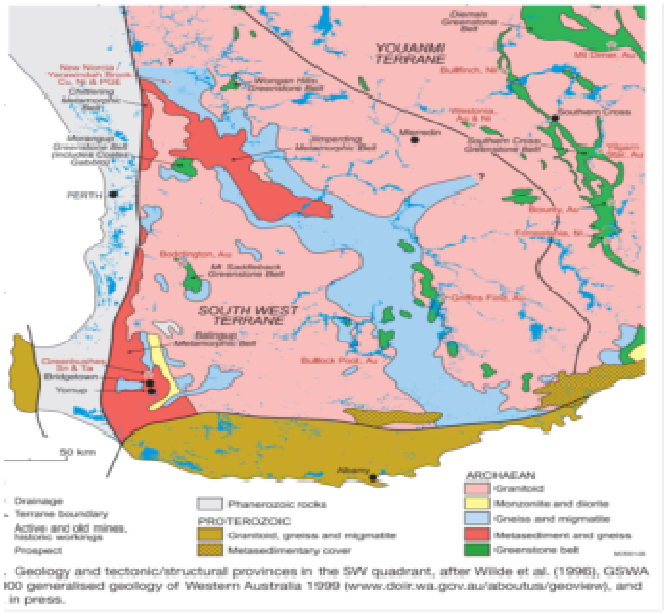
Trevor Syme, Bolgart, 2010 paddock strips						
			heads /M^2	BY kg/ha	GY kg/ha	HI %
Mouldboard Gravel			235	5584	2696	48
Spaded Gravel			180	3501	1483	42
	No Till Gravel		126	1837	731	40
Mouldboard Sand			110	1499	534	36
	Spaded Sand		141	1230	388	32
	No Till Sand		64	510	143	28

Laterite geochemical types in relation to Geological provinces of the SW Yilgarn Craton



Wodjil /Campestris laterites

Jarrah forest laterites



. Geology and tectonic/structural provinces in the SW quadrant, after Wilde et al. (1996), GSWA 00 generalised geology of Western Australia 1999 (www.doir.wa.gov.au/aboutus/geoview), and in press.

Changes down the profile are possible