COMPARISON OF HERITAGE AND MODERN CROP CULTIVARS IN RESPONSE TO IRRIGATION AND NITROGEN MANAGEMENT

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ABSTRACT

There is a resurgence of interest in heritage crop cultivars (potatoes, squash and yams) in New Zealand because of the premiums farmers get at niche markets. However, a paucity of information in relation to their growth characteristics and resource use efficiency limit successful management of these crops. This research compares the response of different heritage and modern crop cultivars to irrigation, nitrogen (N) fertiliser and canopy management. Some heritage cultivars produced as much marketable yield as modern cultivars while other heritage cultivars had low yields. Modern potatoes were more responsive to irrigation and N than heritage potato crops (collectively known as Taewa). Application of more than 80 kg N ha^{-1} decreased yield in Taewa (Moe Moe, Tutaekuri) whereas, it increased the yield of modern potatoes (Agria, Moonlight). Full irrigation (FI) increased yield in modern potatoes and Moe Moe. In contrast, Tutaekuri yield was greatest with partial irrigation (PI). FI and 80 kg N ha^{-1} are recommended for Moe Moe production whereas PI and less than 80 kg N ha^{-1} are recommended for Tutaekuri. In addition, greater tuber dry matter and low sugar content suggest that Taewa would have better cooking and processing qualities than modern potatoes. Heritage crops required more water than modern crop cultivars because they mature later. There was high 'water use efficiency' in heritage pumpkin squash; high 'irrigation water use efficiency' in modern potatoes and high 'economic water productivity' for heritage potatoes and pumpkin squash. Heritage crop cultivars adapted to water deficit by developing more roots, higher photosynthetic WUE and leaf water potential than modern cultivars. Although total biomass production was similar, heritage crops tended to produce less marketable yield than modern cultivars because of excessive vegetative growth and potato psyllid infestation. Two strategies to manage the canopy and reduce vegetative growth using chlorocholine chloride (CCC) and mechanical topping were developed. Both strategies increased marketable yield in Taewa by 32 - 44%. Application of CCC at 25 and 50 days after emergence (DAE) was recommended for irrigated Taewa, whereas mechanical topping and application of CCC at 25 and 30 DAE were recommended for both irrigated and rain-fed Taewa. The study also observed that potato psyllid need to be controlled up to 170 DAE in Taewa to avoid yield loss equivalent to NZ$10, 485 to NZ$17, 412 per ha. This study contributes to policy on sustainable and improved Maori land use. It can be concluded that premium market prices are important to the success of heritage crops (i.e. to maintain their high 'economic water productivity') whereas modern crops might use irrigation water more efficiently (i.e. greater 'water use efficiency'). It is evident that heritage crops can be grown successfully, and that on occasions they use valuable resources efficiently. To enhance water use efficiency, management of heritage crops should focus on improving the harvest index.

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What is the Meaning of Life in a Meaningless World, "Vanity of vanities? (Ecclesiastes 1:1-2). The meaning of life is in Christ Jesus "For we are His workmanship, created in Christ Jesus for good works, which God prepared beforehand, that we should walk in them." (Ephesians 2:10). But as many as received him, to them he gave power to become the sons of God, even to them that believe on his name (John 1:12).

CANDIDATE'S DECLARATION

This is to certify that the research carried out for my Doctoral Thesis entitled: "*Comparison of water use efficiency in heritage and modern crop cultivars in response to irrigation and nitrogen management*" in the Institute of Natural Resources, Massey University, Turitea Campus, New Zealand, is my own work, and that the thesis material has not been used in part or whole for any other qualification.

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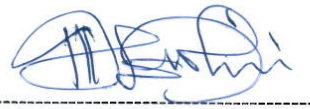
SIGNATURE : 

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GLOSSARY AND ABBREVIATIONS

ANOVA	Analysis of variance
A_n	Net photosynthesis
Ca	Calcium
CCC	Chlorocholine choline,
CWP	Crop water productivity
CWU	Crop water use or consumptive water use
^oC	Degree centigrade
CEC	Cation exchange capacity
Ci	Internal carbon concentration
DAE	Days after emergence
DAP	Days after planting
DII	Drought Intensity index
DM	Dry matter content
EWP	Economic water productivity
ET_c	Crop evapotranspiration
ET_o	Reference evapotranspiration
FI	Full irrigation
GLM	General Linear Model
GM	Geometric mean
g_s	Stomatal conductance
HI	Harvest index %
IWMI	International Water Management Institute
IWUE	Irrigation water use efficiency
Kg ha^{-1}	Kilogram per hactare
Kg ha^{-1} m^{-3}	Kilogram per hactare per cubic meter
K	Potassium
Kc	Crop coefficient
LAI	Leaf area index
LDMC	Leaf dry matter content
LSD	Least Significant Difference
LT	Leaf temperature
MAFF	Ministry of Agriculture, Forestry and Fisheries
MRZ	Maximum root zone

MAD	Maximum allowable deficit
m^3 ton^{-1}	Cubic meter per tonne
Mg	Magnesium
N	Nitrogen
Na	Sodium
NUE	Nitrogen use efficiency
NH_4^+-N	Ammonium-Nitrogen
NO_3^--N	Nitrate-Nitrogen
NPV	Net present value
PAR	Photosynthetically active radiation
PRD	Partial root-zone drying
PI	Partial irrigation
PR	Percentage reduction
PWUE	Photosynthetic water use efficiency
P_e	Rain-fed
P	Phosphorus
RCBD	Randomised complete block design
SAS	Statistical Analysis System software
SEM±	Standard error of mean
SG	Specific gravity
SLA	Specific leaf area
SPAC	Soil–Plant–Atmospheric Continuum
SMD_c	Critical soil moisture deficit
SWC	Soil water content
T	Transpiration rate
t ha^{-1}	Tonnage per hectare
TDR	Time-Domain Reflectometer
URI	Uniform variable irrigation
WF	Water footprint,
WUE	Water use efficiency,
VPD	Leaf vapour pressure deficit
VRI	Variable rate irrigation
VWC	Virtual water content