# Manchurian wild rice (*Zizania latifolia*) biomass allocation and implications for control

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**Summary** Manchurian wild rice (*Zizania latifolia*) is a giant invasive grass that forms dense monospecific stands of vegetation on the margins of water bodies, also invading flood-prone pasture and cropping land. A national eradication programme has been initiated for this species.

Biomass for component parts of the plant was measured in pot and field trials. In the field Manchurian wild rice produced a total biomass of 109.9 tonnes dry weight ha$^{-1}$, with ~80% of this biomass below ground (mostly rhizomes). Of the shoot biomass, 41.4% is dead and in pot trials this percentage was higher. The dead biomass was predominantly comprised of shoot bases with large amounts of aerenchymous tissue that, therefore, could act like a sponge to herbicide application. This may explain the poor control obtained with various herbicide treatments. This paper describes proposed field trials to pre-treat stands of this plant by burning, crushing or mowing prior to herbicide treatment. After these pre-treatments the efficacy of haloxyfop, imazapyr and glyphosate will be evaluated.

**Keywords** Biomass, eradication programme, herbicide trial.

## INTRODUCTION

Manchurian wild rice (*Zizania latifolia* (Griseb.) Turcz. ex Stapf) is a giant emergent perennial rhizomatous grass, growing up to 4 m tall. Plants are comprised of basal fans of leaves (up to 2 cm wide) arising from a bulky, deep rooting and far-spreading rhizome system. Plants form dense, monospecific vegetation in wetlands and on the margins of water bodies, also invading flood-prone pasture and cropping land. Obstruction of drains by this plant promotes flooding and expands the habitat available to it.

It has a limited distribution in New Zealand mostly centred around Dargaville in Northland, which was its site of introduction in the 1900s. Here it occupies approximately 338 ha along 60 km of the Northern Wairoa River, with sixteen outlier populations in western Northland (Joynt and Newby 1998). Additional sites are found in other parts of Northland (Kauri and Whangarei), Auckland (Lakes Kereta and Karaka on the South Head of the Kaipara, Helensville, Laingholm and Mangere), Waikato (Waihou, Piako and Awaiti Rivers on the Hauraki Plains and Horohoro and Lake Te Koutu near Cambridge) and Wellington (Waikanae) (Champion and Hofstra 2008).

MAF Biosecurity New Zealand has instigated a National Interest Pest Response (NIPR) Programme on this species, with the initial aim of eradicating all sites outside of the Northern Wairoa River, with national eradication the long-term goal (Anon. 2009).

Manchurian wild rice is notoriously difficult to control using herbicides, with glyphosate, or a combination of dalapon and amitrole, the most commonly used to date (P. Joynt, Northland Regional Council, pers. comm.). Neither gave long-term control even when used at very high rates, with strong regrowth persisting after many re-applications of these herbicides. NIWA trials have led to the use of haloxyfop-P methyl in the current eradication programme (Champion *et al.* 2001), with twice annual application (late spring, early autumn) at 700 g a.i. ha$^{-1}$.

This paper details the estimation of Manchurian wild rice biomass, including above- and below-ground biomass, and the amount of dead shoot material (trash) present in natural stands of this species, in order to optimise effective control of this weed. Proposed pre-treatment of Manchurian wild rice stands to reduce trash, and a herbicide trial comparing haloxyfop-P methyl with imazapyr and high rates of a new formulation of glyphosate (Roundup™ Transorb®) are also outlined.

## MATERIALS AND METHODS

A large area of unmanaged Manchurian wild rice was located on the Northern Wairoa Experimental Farm, on the margin of the Kaihu River, near Dargaville. A block of ten 1 m$^2$ quadrats was established within the stand, over 5 m from the edge. All shoot material within each quadrat was harvested and divided into living and dead matter. A digger was used to excavate soil over the entire 10 m$^2$ block, sampling in 20 cm depth increments. All root and rhizome material was separated from soil and subsequently washed to remove any additional soil. Plant material was dried in a forced fan drying oven at 80°C and weighed.

These data were compared with pot trial biomass data gained from control plants of earlier Manchurian wild rice herbicide trial work from 2001 (NIWA unpublished data).

## RESULTS

Table 1 presents biomass data collected for both field and pot trials. Field assessed data equates to a total biomass of Manchurian wild rice of 109.9 T ha$^{-1}$. All but 50 kg ha$^{-1}$ of the underground biomass was situated in the top 20 cm of soil.

**Table 1.** Number of shoots and biomass of above and below ground components of Manchurian wild rice (*Zizania latifolia*) sampled from pot and field trials. Standard error in parentheses.

| | Pot trial | Field trial |
|---|---|---|
| Number of green shoots m$^{-2}$ | 25.00 (±2.65) | 34.30 (±1.94) |
| Shoot biomass (kg m$^{-2}$) | 5.33 (±0.33) | 2.99 (±0.25) |
| Green shoot biomass (kg m$^{-2}$) | 2.25 (±0.13) | 1.75 (±0.17) |
| Dead shoot biomass (kg m$^{-2}$) | 3.08 (±0.20) | 1.24 (±0.12) |
| Below ground biomass (kg m$^{-2}$) | 6.37 (±0.15) | 8.00 |
| Below ground biomass (kg m$^{-3}$) | 18.04 (±1.86) | 40.02 |
| Total biomass (kg m$^{-2}$) | 11.67 (±0.46) | 10.99 |

## DISCUSSION

Field and pot trial assessment of biomass gave higher values than the range of biomass reported for Manchurian wild rice in the literature. Highest shoot biomass estimates for this species were obtained by Tanner (1996). He compared the above- and below-ground biomass of eight emergent species grown in gravel bed wetlands receiving dairy farm wastewater. He estimated a shoot biomass of 3.8 kg m$^{-2}$ and a total biomass of 7.4 kg m$^{-2}$ (Tanner 1996). This was the highest biomass of all species estimated in his study. Field estimates from Japan (within the indigenous range of this species) reported above- and below-ground biomass of 1.6 and 2.4 kg m$^{-2}$ respectively (Tsuchiya *et al.* 1993). Tanner (1996) had only grown plants for 4 months, which may explain the low percentage of underground biomass (51.4%), with elevated nutrient levels also likely to increase shoot to root ratio (Barko and Smart 1978). Introduced species often perform better outside of their native range, being free of natural predators and pathogens. For example, most indigenous stands of Manchurian wild rice are infected by the smut fungus *Ustilago esculenta* P.Henn. (Chan and Thrower 1980).

The dead shoot component (trash) was primarily comprised of large basal leaf sheaths. These contained large air spaces (lacunae) typical of aerenchymous tissues, an adaptation to permit oxygenation of underground parts growing in waterlogged soils (Yamasaki 1987). This adaptation would also allow these dead sheaths to absorb large amounts of water (akin to a sponge) and therefore could reduce the effectiveness of herbicide application by absorbing this.

Field trials using haloxyfop-P methyl, imazapyr and quizalofop were conducted by Champion *et al.* (2001) with associated pot trials using these products (NIWA unpublished data). In the field, two applications of herbicide were made in November and April, using 0.5 and 1.0 kg a.i. ha$^{-1}$ of haloxyfop-P methyl and quizalofop, and 1.0 and 1.5 kg a.i. ha$^{-1}$ of imazapyr. This resulted in percentage cover of Manchurian wild rice shoots of 26.25% (±2.39 SE) for both quizalofop treatments, 11.25% (±3.75 SE) for haloxyfop and 5.25% (±1.65 SE) for imazapyr 10 months after the second herbicide application. This compares with shoot biomass data obtained from pot trials using the same rates as follows: 0.65 (±0.05 SE) kg m$^{-2}$ and 0.61 (±0.15 SE) kg m$^{-2}$ for the lower and higher rate of haloxyfop and 0.67 (±0.10 SE) kg m$^{-2}$ and 0.60 (±0.09 SE) kg m$^{-2}$ for the lower and higher rate of imazapyr. There was no significant difference in shoot biomass between quizalofop and untreated plants. Control plants had a biomass of 5.33 (±0.33SE) kg m$^{-2}$, so reduction in biomass of approximately an order of magnitude was attained. However, biomass of underground parts was not significantly reduced in any of the treatments. Differentiation of living and dead rhizomes (the major component of underground biomass) was not attempted, so the impact of herbicide treatments on regrowth was not quantified (NIWA unpublished data). Based on these trials haloxyfop was chosen as the herbicide to be used for subsequent Manchurian wild rice control activities and the NIPR eradication programme as it was less expensive and more readily available than imazapyr.

An upcoming herbicide trial scheduled for spring 2010, will more critically compare the performance of these two herbicides, along with a new formulation of glyphosate (Roundup™ Transorb®) that is effective at high rates (T. James, AgResearch, pers. comm.). This trial will be based on lines of twelve 100 $m^2$ plots, with a 1 m gap between each plot, which have been established (in November 2009) parallel to the Kaihu River in the large area of unmanaged Manchurian wild rice on the Northern Wairoa Experimental Farm. Unfortunately the drought in Northland prevented a controlled burn in summer/early autumn 2010, thus delaying pre-treatment and subsequent herbicide application.

Each line of plots will receive a different pre-treatment as follows:

1. Spray with paraquat at 1.5 kg $ha^{-1}$ and then burn following brown out.
2. Flatten with a roller crusher.
3. Harvest with a mower.
4. Control.

Once vegetation has re-grown to between 0.5 to 1 m tall, three replicate plots, randomly selected in each line are due to receive the following herbicide treatments in spring 2010 and again in late autumn 2011:

1. Haloxyfop-P methyl at 700 g a.i. $ha^{-1}$.
2. Imazapyr at 1.5 kg a.i. $ha^{-1}$.
3. Glyphosate (as Roundup™ Transorb®) at 10.8 kg a.i. $ha^{-1}$.
4. Control.

All plots will be assessed for plant height and percentage cover at 6 monthly intervals after herbicide application and biomass assessed in autumn 2012.

Potted plants of Manchurian wild rice grown in 60 L, 0.22 $m^2$ containers for 3 years will also receive the same range of herbicide treatments at the same time as the field plots, with 50% of pots only receiving the spring treatment. All trash will be hand-removed prior to herbicide application. Assessment of plant height, percentage cover and biomass will be carried out at the same time as the field plots. Viability of underground parts will be assessed by sub-sampling at the time of harvest and assessing regrowth in shallow trays.

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