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VI Influence of adjuvants on the activity of glyphosate products

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When glyphosate is applied under challenging conditions, a tank mix with ammonium sulphate is recommended. Another adjuvant recommended for glyphosate is NovaBalance that specifically should reduce the negative effects of hard water. The latest glyphosate products are claimed to contain a surfactant composition maximising leaf uptake. Faster leaf uptake means shorter cultivation intervals and higher reliability under challenging conditions. Consequently, the benefit of applying the new glyphosate products in a tank mix with adjuvants is expected to be lower. In this study we compared the activity of three generations of glyphosate products: (1) acting alone, (2) mixed with ammonium-sulphate + a non-ionic surfactant and (3) mixed with NovaBalance + a non-ionic surfactant. All three glyphosate products showed significantly higher activity in the tank mix with ammonium-sulphate compared to using either no adjuvant or NovaBalance. These results illustrate that the new glyphosate products Roundup Flex and Roundup PowerMax can still benefit from being tank mixed with ammonium-sulphate + a surfactant.

Three glyphosate products commonly available to Danish farmers were examined. Firstly, Glypper (360 g/l glyphosate, previously known as Taifun 360 SL), which was authorised for use in Denmark in 2012. Secondly, Roundup Flex (480 g/L glyphosate), which belongs to the second generation of glyphosate products with a higher concentration of glyphosate and a shorter cultivation interval (6 hours for annuals, 2 days for couchgrass and 5 days for perennials). Finally, Roundup PowerMax (720 g/kg), which - being authorised in 2015 - is the most recent formulation of glyphosate on the Danish market. In contrast to the other two products Roundup PowerMax is a granular formulation. Cultivation intervals are similar to those of Roundup Flex, with an additional claim of less sensitivity to hard water.

We compared the efficacy of these three glyphosate products: (1) acting alone, (2) in a tank mix with 2 kg/ha ammonium-sulphate + 0.2% Contact (a non-ionic surfactant) and (3) with 0.2% NovaBalance + 0.2% Contact (Table 1). NovaBalance is a chelating, complex binding adjuvant which inactivates the cations and regulates the pH of the spray liquid. The experiment was carried out on two test weeds: rat's-tail fescue (*Vulpia myuros*) and black bindweed (*Polygonum convolvulus*).

The test weeds were grown outdoors in a potting mix consisting of sand, soil and peat, which included all necessary micro- and macronutrients. Rat's-tail fescue was sown in 1-L pots, and after germination the number of plants per pot was reduced to eight. The plants were sprayed at the 3-4 leaf stage on 3 August. The germination of black bindweed seeds is often low and uneven, and in order to generate uniform plants the seeds were sown in trays in the glasshouse and the seedlings were transplanted into 1-L pots (3 plants per pot) at the 1 leaf stage. The black bindweed was sprayed at the 3-4 leaf stage, on 4 July.

All spray solutions were prepared in tap water with a hardness of 17 °dH. Herbicide applications were carried out in a spray cabinet. Each treatment was applied at five doses in a spray volume of 150 L/ha. The doses ranged from 15 to 240 g/ha with three replicates per treatment. The plants were harvested three to five weeks after spraying. Fresh and dry weight were recorded.

A dose-response model was fitted to the data and the ED_{90} doses were estimated (Table 1).

Results and discussion

On both weed species the activity of the three glyphosate products was not significantly different three to five weeks after spraying when the herbicides were applied alone. The tank mix containing NovaBalance + Contact did not affect the activity of the three products. In contrast, the activity of all glyphosate products was significantly enhanced in the tank mix containing ammonium-sulphate + Contact. The ED_{90} doses of Glypper and Roundup Flex were reduced by 65-70% and those of Roundup PowerMax by 73-75% when tank mixed with ammonium-sulphate + Contact compared to the treatments with no adjuvant.

Several environmental factors are known to affect the activity of glyphosate. The uptake of glyphosate is reduced at low air humidity and in plants growing under dry soil conditions, while it is less affected by temperature. High concentrations of cations in the spray solutions inactivate glyphosate by complex binding (Kudsk and Mathiassen, 2007). At the time of spraying the water status of the test plants was good, the air temperature was high (16 to 22°C), the air humidity was medium (62 to 73%) and the herbicide solutions were prepared in water with a high content of cations (100 mg/L Ca, 12 mg/L Mg). In conclusion, water quality was the most challenging factor and therefore it was expected that Roundup PowerMax would perform better than Roundup Flex and Glypper when applied alone.

Table 1. Estimated ED_{90} doses of different glyphosate products when applied alone or in mixture with 2 kg/ha ammonium sulphate (AMS) + 0.2% Contact or 0.2% NovaBalance + 0.2% Contact. Figures in brackets are 95% confidence intervals.

Glyphosate product	Adjuvant	Rat's-tail fescue	Black bindweed
Glypper	None	249.5 (157.4-341.6)	202.7 (121.1-284.3)
	AMS + Contact	85.7 (56.2-115.1)	62.4 (37.2-87.5)
	NovaBalance + Contact	228.9 (160.3-297.6)	190.5 (146.4-234.6)
Roundup Flex	None	276.6 (179.3-373.8)	176.8 (129.2-224.3)
	AMS + Contact	89.4 (69.8-109.0)	61.0 (37.76-84.2)
	NovaBalance + Contact	250.5 (189.3-311.5)	184.4 (134.8-234.1)
Roundup PowerMax	None	224.3 (176.6-271.9)	209.0 (139.3-278.7)
	AMS + Contact	61.0 (44.8-77.1)	51.7 (27.6-75.8)
	NovaBalance + Contact	196.8 (153.4-240.2)	183.2 (94.6-271.8)

In a previous study we reported that NovaBalance and ammonium-sulphate increased the effects on couchgrass of Glyphogan, Glyfonova 480 and Roundup Flex, applied in carrier water with a high content of cations (Mathiassen, 2017). In contrast, NovaBalance was not able to inactivate the cations in the spray solutions in this study. These results illustrate that in spite of the improvement in formulation of glyphosate products over time, the new formulations still benefit from tank mixing with ammonium-sulphate + surfactant when applied under adverse application conditions – exemplified in this case by water with a high content of cations.

Black bindweed treated with Roundup PowerMax. From left to right: Untreated, 30, 60, 120 and 240 g/ha. From back to front row: No adjuvant, ammonium-sulphate + Contact and NovaBalance + Contact.

References

Kudsk, P. and S. K. Mathiassen (2007). Analysis of adjuvant effects and their interactions with variable application parameters. Crop Protection 26: 328-334.

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