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# Weed control efficacy of a novel dicamba-based nano-herbicide formulation

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## Introduction

Conventional agrochemicals are a widely used option to control pests and have historically resulted in a noticeable increase in food production and crop yields to feed humanity. Despite these benefits, the use of agrochemicals can pose numerous drawbacks, such as health risks and environmental problems. New pesticide nanoformulations have the potential to enhance productivity, while reducing or mitigating the referred issues (Kumar *et al.*, 2019). Dicamba, one of the most widely used hormonal herbicides, has been used for decades to control broadleaf weeds, but new formulations containing dicamba still caused environmental problems, such as off target movement on surrounding vegetation due to volatilization processes and water contamination due to its high solubility (Pernak *et al.*, 2020).
In this context, a project named NANOGRASS aims at developing a new mineral-based dicamba nanoformulation (DNF), encapsulated with food-grade biodegradable materials, that has the potential to show a good weed control duration by preventing the premature degradation of active substances (a.s.), while limiting the dispersion in the environment. The aim of the study was to assess weed control efficacy of this new nanoformulation compared to a commercial formulation. A quick test was conducted in Petri dishes to verify the effectiveness of the nanoformulation in pre-emergence applications (PRE test), while two greenhouse tests were conducted to assess the efficacy in POST emergence applications (POST 1 and POST 2 tests).

## Materials and Methods

PRE test was performed in Petri dishes as a quick test sowing 20 seeds for both *Centaurea cyanus* L. (CENCY) and *Amaranthus retroflexus* L. (AMARE) for each dish lined with a filter paper and adding 5 ml dicamba solutions at 4 different concentrations (0 - 0.24 - 0.85 – 1.46 $g_{a.s.}$/L). Four replications for each concentration were prepared and kept in a climatic chamber at 25 °C. Products tested were commercial standard *Mondak 21S* (COM) and DNF. After 8 days, germination % and radicle+ipocotile length were measured. POST greenhouse tests were performed in plastic pots filled with professional grade potting mix and seeded with four weed species: *Centaurea cyanus* L. (CENCY), *Abutilon theophrasti* Medik. (ABUTH), *Chenopodium album* L. (CHEAL), and *Amaranthus retroflexus* L. (AMARE). At 3-4 leaf stage the plants were treated with either COM or DNF using a spray cabinet at 3 dicamba doses: 98 – 195 – 293 $g_{a.s.}$/ha. Untreated plants were added as control. Twenty days after treatment the effects of the applied products on the weeds were assessed by measuring their fresh aerial biomass. POST1 test assessed DNF weed control efficacy and shelf life, comparing fresh DNF, stored DNF (3 months) and COM. POST2 test assessed if the addition of a commercial adjuvant (*Dash HC, BASF*) (ADJ) increased the weed control efficacy of DNF and COM. ADJ was used at maximum dose (5% v/v). All tests had three replications in a randomized setup. T-test and one way ANOVA were conducted and means were separated by REGWF post hoc test ($\alpha \leq 0.05$).

## Results

**PRE test**: treatments at medium and maximum doses on AMARE showed significant differences, always showing lower germination with DNF, with values lower than 1% (Table 1). AMARE radicle+ipocotile length was significantly lower at every dicamba dose when treated with DNF (at maximum dose, mean lenghts were 1.6 and 0.23 mm in COM and DNF, respectively). CENCY did not show significant differences between COM and DNF (at highest dose, germination and length were 18 - 7% and 0.5 - 0.17 mm in COM and DNF, respectively), while both treatments were significantly different from control (68% germination, 2 mm radicle+ipocotile length).

Table 1. AMARE germination percentage in PRE test. Same letters represent non-significant differences between COM and DNF at each concentration according to t test ($\alpha \leq 0.05$).

| | Treatment concentration (g/L) | | | |
|---|---|---|---|---|
| Products | 0.24 | 0.85 | 1.46 | control |
| COM | 42% a | 16% b | 17% b | 58% |
| DNF | 35% a | 0% a | 1% a | |

**POST1 test**: at lower dose fresh DNF and COM resulted in similar biomass, while plants treated with stored DNF weighed significantly more (1.26, 1.39 and 2.10 g/plant in COM, DNF-fresh and DNF-stored, respectively), even though it was not dissimilar from control (1.65 g/plant) (Figure 1A). At medium and maximum dose no differences were found among formulations, which showed no differences with the control. No differences were found on ABUTH among treatments (0.31, 0.34, 0.45, 0.44 g/plant at medium dose in COM, DNF-fresh, DNF-stored and control, respectively).
**POST2 test**: in AMARE, aerial biomass in untreated control averaged about 0.30 g/plant and this value was significantly higher than that of the treated plants (Figure 1B).
In CHEAL, aerial biomass in untreated control averaged 0.27 g/plant; no significant differences were recorded among all the tested formulations except at the maximum dose, where DNF+ADJ showed lower biomass; at the highest doses the treated plants with all the formulations showed significantly lower biomass than untreated control (Figure 1C).

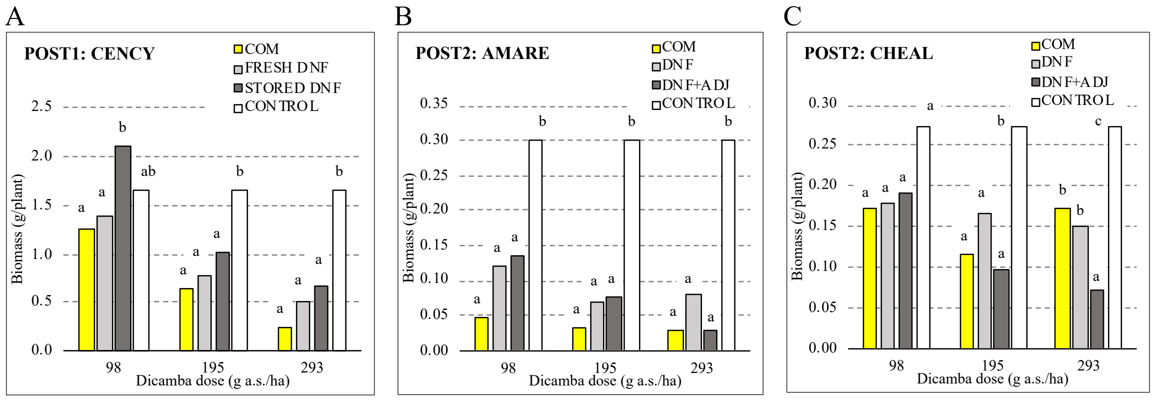


Figure 1. A. CENCY biomass at three tested dicamba doses of treatment COM, FRESH DNF, STORED DNF and CONTROL. B. AMARE biomass at three tested dicamba doses of COM, DNF, DNF+ADJ and CONTROL. C. CHEAL biomass at three tested dicamba doses of COM, DNF, DNF+ADJ and CONTROL. Same letters indicate non-significant differences (REGWF test, $\alpha \leq 0.05$) among treatments at a same dicamba dose.

## Conclusions

In general, DNF showed high weed control efficacy at the tested medium and maximum dicamba doses. DNF reduced weed germination percentage when applied in PRE emergence, in particular on AMARE. In POST emergence DNF had the same weed control efficacy as COM. Stored DNF was less effective than COM when applied on CENCY at lower dose, thus shelf-life could further be investigated in DNF. In CHEAL, the use of adjuvants improved control efficacy in comparison with DNF alone.

## Literature

Kumar S. et al. 2019. Nano-based smart pesticide formulations: Emerging opportunities for agriculture. J. Controll. Release, 294: 131–53.
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