Analysis of N Use Efficiency of Maize to Optimise N Fertiliser Application under Weed Competition

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Introduction

- Cropping of maize is characterized by high N-surplus due to over-fertilization.
- This not only increases the likelihood of N leaching but also favors weed growth under competition conditions.
- Weeds are strong competitors for N.
- Mechanistic understanding of crop and weed responses to N is essential for the development of strategies that reduce the nutrient availability to weeds and also to optimize N application rate.
- A good criterion to achieve the above goal is crop nitrogen use efficiency (NUE).
- NUE is the product of two components: nitrogen uptake efficiency (NUpE) and nitrogen utilization efficiency (NUtE).
- It seems that competition for nutrients plays a more important role in yield loss of maize as a result of weed competition.

Methodology

- A two-year field experiment was conducted in 2008 and 2009 at Tarbiat Modares University, Tehran.
- The climate is arid and semi-arid with long-term average annual rainfall and temperature of 232.6 mm and 17.6°C, respectively.
- Experimental factors were:
  - N fertilizer rates: 138, 184 and 230 kg N ha^{-1}
  - Weed species: redroot pigweed (*Amaranthus retroflexus* L.) and proso-millet (*Panicum miliaceum* L.)
  - Weed densities: Low and high (5 and 25 plants m^{-2} in redroot pigweed; 7.5 and 37.5 plants m^{-2} in proso-millet).
- At physiological maturity, crop yield and N attributes were measured.

Maize and redroot pigweed

Maize and proso-millet

Weed-free maize

Research objectives

Objective 1: To explore how different weed species affect maize yield.

Objective 2: To examine the effects of weed competition on maize yield loss through dissecting NUE into its components.

Results and discussion

- Proso-millet was more troublesome in maize compared to redroot pigweed.
- Proso-millet was most damaging under lowest N fertilization treatment while redroot pigweed was most damaging under highest N rate.
- High density of proso-millet was more damaging than its low density. However, low density of redroot pigweed was as damaging as its high density.
- NUE was negatively affected by both weed species.
- NUpE was the main contributing factor to the N status of the crop under weed competition.
- This may highlight the more important role of belowground compared to above-ground competition in the determination of the overall result of competition between maize and weeds.

Table 1. Grain yield, nitrogen use efficiency (NUE), nitrogen uptake efficiency (NUpE) and nitrogen utilization efficiency (NUtE) of maize at maturity as affected by N fertilizer rate, and weed species and density.

Treatments		Grain yield (g m^{-2})		NUE (g g^{-1})		NUpE (g g^{-1})		NUtE (g g^{-1})	
Proso-millet	***N rate*** (kg ha^{-1})	2008	2009	2008	2009	2008	2009	2008	2009
	138	463	739	11.12	19.45	0.26	0.39	42.87	49.71
	184	811	710	15.72	14.79	0.26	0.26	60.81	55.13
	230	701	790	11.37	13.62	0.2	0.25	58.4	53.4
	LSD (0.05)	77.05	83.28	1.52	1.68	0.02	0.04	6.27	7.18
	Density								
	Low	704	800	13.65	17.07	0.23	0.32	59.16	54.93
	High	612	693	11.82	14.83	0.24	0.29	48.89	50.57
	LSD (0.05)	62.91	68.00	1.24	1.37	0.02	0.03	5.12	5.78
Redroot pigweed									
	N rate (kg ha^{-1})								
	138	725	768	17.41	20.21	0.27	0.39	65.16	52.47
	184	736	832	14.26	17.32	0.24	0.35	57.8	50.22
	230	740	633	12.01	10.9	0.21	0.22	55.31	49.66
	LSD (0.05)	193.61	158.15	3.78	3.52	0.06	0.06	14.54	14.41
	Density								
	Low	754	795	14.95	17.21	0.24	0.33	60.8	52.89
	High	713	693	14.17	15.08	0.24	0.31	58.04	48.68
	LSD (0.05)	158.08	129.13	3.09	2.87	0.05	0.05	11.87	11.77

Figure 1. The association between maize grain yield (GY) and its NUE, NUpE and NUtE.

▲: Weed-free maize.

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Maize competing with low and high densities of proso-millet and redroot pigweed at 138, 184 and 230 kg N ha^{-1}, respectively.

Conclusion

- Generalization of the results showed a critical value of 15 g g^{-1} for maize NUE under weed competition, below which grain yield declines sharply.
- It could be concluded that improvement of NUE and its components, especially NUpE, will be a significant step towards rationalizing the use of N fertilizer and selection of genotypes/agronomic strategies that results in better adaptation to low N environments under weed presence.