Maize-Lupine Intercrop Response to Applied Nitrogen and Phosphorus in Northwestern Ethiopia

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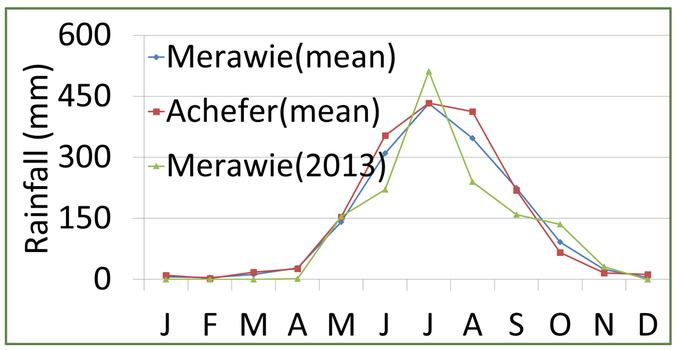
Maize (*Zea mays* L.) is a major staple crop and sweet narrow leaf lupine (*Lupinus angustifolius*) is a potential animal feed. In other research, the maize-lupine intercrop compared with sole crop was more productive. Research was conducted to: 1) determine intercrop maize and lupine yield response to applied N and P, and N use efficiency by maize; and 2) establish the basis for determining the most economical N and P rates with varying costs and commodity prices for the intercrop.

Methods. The nutrient rates were 0, 64, 128 and 192 kg N ha^{-1} and 0, 20, 40 and 60 kg P ha^{-1} arranged in complete factorial RCB design with three replications. Both crops were planted the same day in an additive series with 100% and 40% of sole crop maize and lupine stands, respectively (Fig.2).



Trials were conducted at Achefer (N 11^{O}20', E 36^{O}56', 2021 masl) and Merawie (N 11^{O}23', E 37^{O}06', 1982 masl) in 2013. The locations had low pH and low P clay soil. Both locations have mono-modal rainfall pattern (Fig.1).

Fig. 1. Monthly rainfall distribution for trial sites.

Fig. 2. Maize-lupine intercropping.

Results. Maize responded to applied N and P with NxP interaction at both locations (Fig. 3). Yield increased with nutrient rate but declined at the maximum rates. Averaged over P, yield ranged from 3.05 to 6.49 and from 1.50 to 7.12 Mg ha^{-1} at 0 kg N ha^{-1} and the optimal N rate, respectively, in Achefer and Merawie. Yield averaged over N rates ranged from 3.73 to 6.10 and from 2.44 to 6.54 Mg ha^{-1} at 0 kg P ha^{-1} and the optimal P rate, respectively, in Achefer and Merawie. Yield responses to N without P application and to P without N application were low.

The polynomial response functions for Achefer [1] and Merawie [2] were:

$Y=2.229+0.0367N+0.07954P–1.41(10^{-4})N^2–1.12(10^{-3})P^2+2.46(10^{-4})NP,\ R^2 = 0.95$ [1]

$Y=0.274+0.0521N+0.137P–1.98(10^{-4})N^2–2.05(10^{-3})P^2+488(10^{-4})NP,\ R^2 = 0.94$ [2]

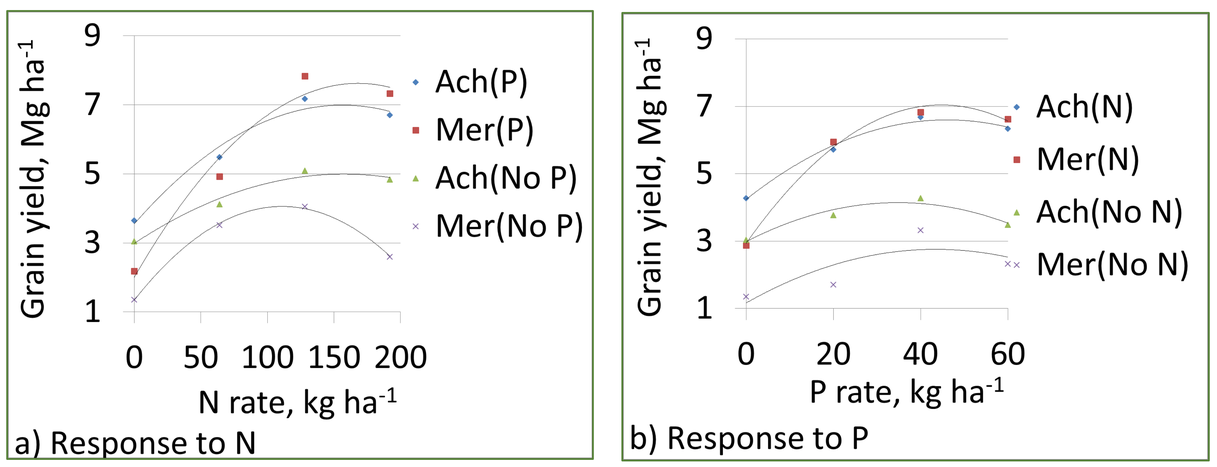


Fig. 3: Maize yield response to applied N and P under maize-lupine intercropping.

Yield ranged from 2.23 at 0/0 N/P to 7.69 Mg ha^{-1} at 178/55 kg N/P ha^{-1} in Achefer, and from 0.27 at 0/0 N/P to 9.45 Mg ha^{-1} at 202/57 kg N/P ha^{-1} in Merawie (Fig. 4).

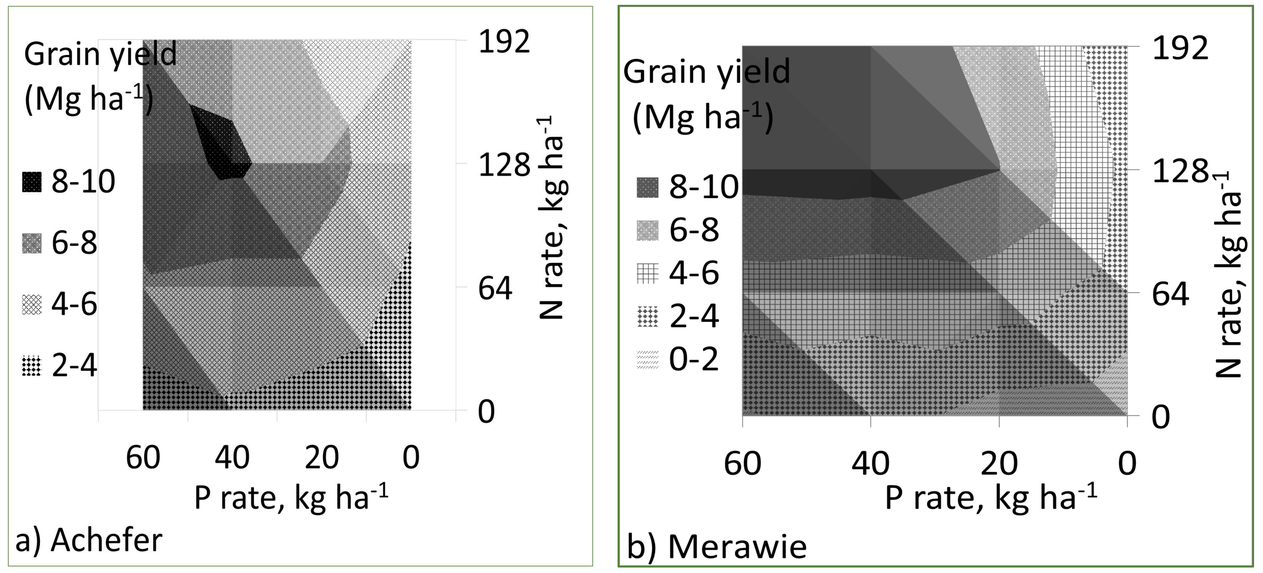


Fig. 4. Response surface of the N*P effect on grain yield of maize under maize-lupine intercropping.

The economically optimum rates (EOR) with N and P cost equal to the value of 6 and 11 kg of grain, respectively, were 150/47 kg N/P ha^{-1} in Achefer and 181/52 kg N/P ha^{-1} in Merawie. When fertilizer cost doubled, EOR declined to 117/37 and 155/46 kg N/P ha^{-1} in Achefer and Merawie, respectively (Fig. 5).

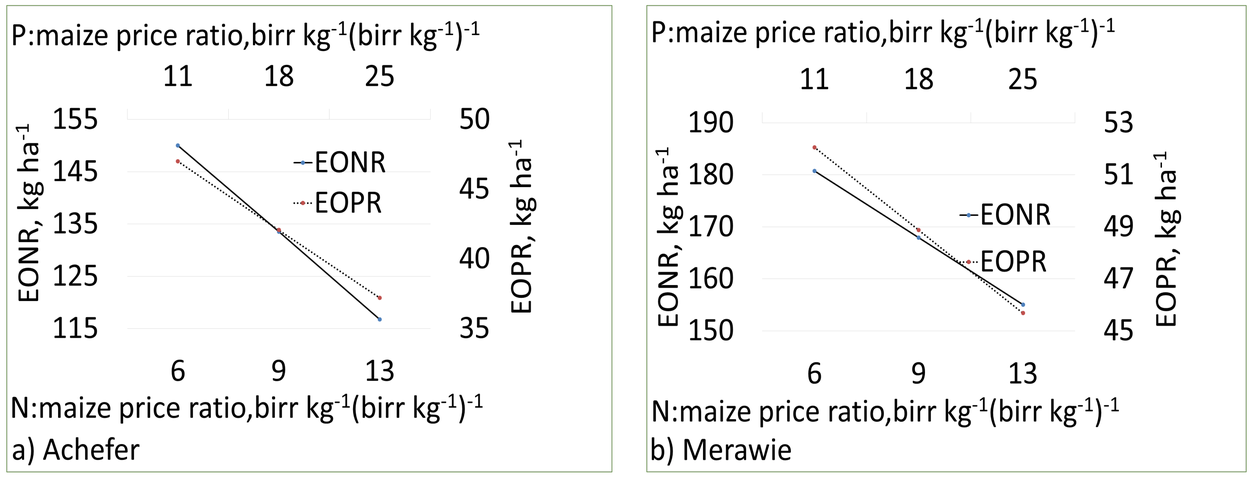


Fig. 5. The effect of cost/price ratio on EONR and EOPR.

Components of N and P use efficiencies declined as nutrient rates increased. N and P use efficiencies were higher for economic optimum nutrient rates and intercropped maize compared with agronomic optimum nutrient rates and sole crop maize. At 117/37 and 155/46 kg N/P ha^{-1} in Achefer and Merawie, respective, efficiencies (kg kg^{-1}) were:

- Agronomic 17 and 25 for N, and 38 and 65 for P;
- Recovery 25 and 34 for N;
- Partial factor productivity 32 and 27 for N, and 114 and 104 for P.

Conclusion and recommendation. Maize grain yields were increased by 5.46 and 9.18 Mg ha^{-1} at EORs of 150/47 and 181/52 kg N/P ha^{-1} as compared to the unfertilized treatment in Achefer and Merawie, respectively, under maize-lupine intercropping. High yield and nutrient use efficiency of maize can be achieved with fertilizer use and intercropping. Seasonal price information is required to determine the EORs which vary with fertilizer cost and grain market prices. Policy and extension intervention is needed to encourage small scale farmers to plant the highly productive maize-lupin interrcrom and to use appropriate N and P rates for this intercrop system.