Site specific fertilizer recommendation for maize in Ethiopia: An analytical approach

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Abstract

Physiological use efficiency (PUE), recovery fraction of applied nutrients and indigenous soil nutrient supply are the basis for site specific fertilizer recommendations to target optimal yield. To derive these parameters and understand maize responses to fertilizer, nutrient omission trials (NOTs) were conducted in farmers' fields in Bako (n=37), Central Rift Valley (CRV) (n=66) and Jimma (n=44) regions of Ethiopia in 2015 and 2016 growing seasons. The treatments used in the trials were control, PK, NK, NP, NPK and NPKSM, where SM refers to secondary and micro nutrients, with 120, 40, 40 kg/ha of nitrogen (N), phosphorus (P) and potassium (K), respectively, and SM applied in low quantities. Soil supply of nutrients was assessed from (1) measurement of soil properties (2) yield responses and (3) plant tissue analysis. The PUE was estimated from the ratio of dry matter (grain) yield to nutrient uptake, whereas recovery fractions were determined from the ratio of uptake to applied nutrients. Lastly, we related target yield to median PUE, soil supply and recovery fractions of nutrients in each region to determine site specific fertilizer recommendation.

Averaged over two seasons, maize yields were 4.5, 5.1, 7.8, 8.2, 8.3 and 8.5 t/ha at 15.5% moisture level in the control, PK, NK, NP, NPK and NPKSM plots, respectively, in Bako. In CRV, the average maize yields were 3.1, 3.2, 4.0, 4.7, 5.0 and 5.1 t/ha, whereas in Jimma, the yields were 2.9, 3.3, 6.7, 7.9, 7.9 and 7.7 t/ha for the same treatments. Nitrogen was limiting grain yield in all the three regions, whereas P limited yield in CRV and Jimma. The average agronomic efficiencies of N under NPK fertilizer use were 25.7, 13.3 and 35.5 kg grain/kg of N applied in Bako, CRV and Jimma, respectively. With the levels used in the NOTs, NK, NP and NPK fertilizers were profitable in Bako and Jimma, whereas PK was not. None of the fertilizer treatments were profitable in CRV. PUE at maximum accumulation, median and maximum dilution of N were 27, 54 and 80 kg DM/kg N, while for P, these values were estimated to be

194, 350 and 505 kg DM/kg P, and for K they were 16, 52 and 87 kg DM/kg K (Figure 1). The estimated average N, P and K recovery fractions were 0.29, 0.05 and 0.06, respectively, in Bako and they were 0.22, 0.10 and 0.15 in CRV, and 0.38, 0.10 and 0.01 in Jimma.

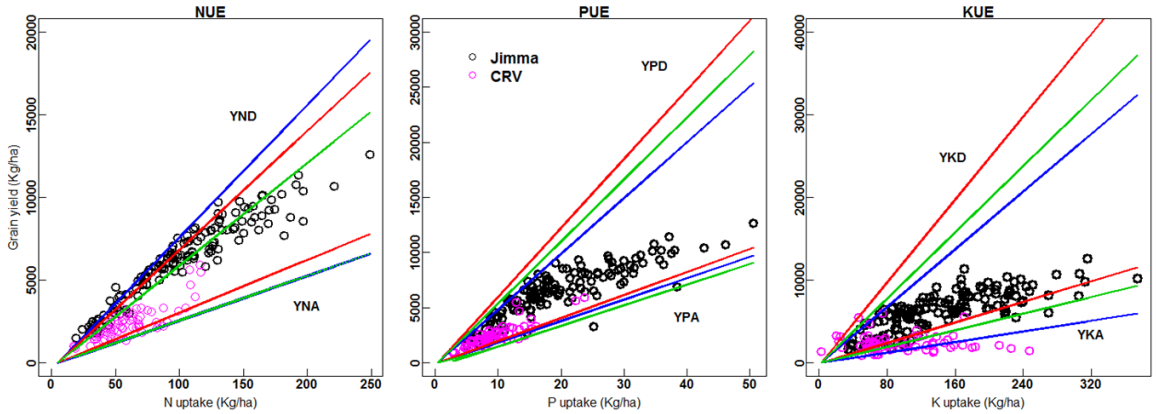

Fig. 1. Relations of maize grain yield and nutrient accumulation in above ground plant dry matter at maturity. The border lines indicate maximum dilution: $Y_iD= d_i (U_i-r_i)$ where i is N, P or K, and accumulation $Y_iA=a_i (U_i-r_i)$ of the nutrients. The blue boundary lines were estimated from NOT data, the red by Janssen et al. (1990) and the green by Sattari et al. (2014).

Based on our analysis, higher fertilizer rates were recommended for maize grown in Bako and Jimma than in CRV. From production and economic perspectives, it is not advisable to use K, secondary and micronutrient fertilizers in the study regions. The variation in indigenous N, P and K supply of soils, differences in recovery fractions and potential yields across regions resulted in variable nutrient quantities to attain the targeted yields. In Bako, 0-134 kg/ha N was required to attain actual yield (3.9 t/ha) whereas 65-224 kg/ha and 245-403 kg/ha N were required respectively for obtaining 50 and 70% of water-limited potential yield (Yw) in the region. In CRV however, 0-85, 0-113 and 50-186 kg/ha N quantities were required to achieve actual (2.6 t/ha), 50 and 70% of Yw yields respectively. Lastly, the N required to achieve actual (3.9 t/ha), 50 and 70% of Yw yields in Jimma based on the variability of N supplying status of fields were 87-179,168-258 and 342-432 kg/ha in respectively.

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