Effects of green manure crops on short-term nitrogen availability in organic sweet corn systems

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This thesis is dedicated to my wife Jolanda.

Your encouragement of me during my tertiary education,

and your support, understanding and faithfulness

have made all the difference.

Thank you!

Abstract

In the Gisborne Region of New Zealand (NZ) many organic sweet corn growers use a range of winter green manure crops as a means of maintaining and improving soil fertility, particularly the availability of soil N. Some debate exists as to the most suitable green manure crops and their effectiveness at improving short-term N availability for subsequent sweet corn crops.

Two field trials were conducted in the Gisborne Region to assess the effectiveness of four winter green manure crops using a subsequent sweet corn crop to evaluate N availability. Two sites, Site-A at Tekaraka and Site-B at Tolaga Bay, with BIO-GROW NZ organic certification were used in this study. A Latin Square trial design was used at each site consisting of 25 plots made up of five replicates of each of the following five treatments: control (bare soil), blue lupin (*Lupinus angustifolus*), mustard (*Brassica sp.*), mustard/blue lupin mix and annual ryegrass (*Lolium multiflorum*).

Just prior to the soil incorporation of green manure treatments (early-mid September 1997), the lupin crop had the highest N concentration and N accumulation levels of 2.1% N and 156 kg N ha^{-1}, respectively, at Site-A and 2.1% N and 173 kg N ha^{-1}, respectively at Site-B. Soil incorporation of green manure treatments significantly influenced soil (0-150 mm) mineral N (nitrate and ammonium) levels measured at sweet corn emergence (30 November 1997) and at 5½ weeks post emergence. At sweet corn emergence the lupin, mustard/lupin mix, mustard, control and ryegrass treatments resulted in soil mineral N values of 68, 66, 57, 51 and 29 $kg.N.ha^{-1}$, respectively, at Site-A and 118, 118, 91, 81 and 54 $kg.N.ha^{-1}$, respectively, at Site B. At both sites, the lupin and mustard/lupin mix treatments resulted in soil mineral N levels significantly higher than the control treatment. In contrast, the ryegrass treatment resulted in soil mineral N levels significantly lower than the control treatment. These treatment effects were related to green manure crop N concentrations just prior to soil incorporation. On average over both sites, the lupin and mustard/lupin mix treatments, which had high DM yields (7900 kg and 6500 $kg.DM.ha^{-1}$ respectively), had the highest N concentrations (2.0% and 2.1% N respectively). The ryegrass treatment, which also accumulated a high average DM yield (6200 $kg.DM.ha^{-1}$), contained the lowest average N concentration of only 1.1 % N.

Sweet corn N accumulation at harvest was also significantly influenced by green manure treatments. At both sites, ryegrass significantly reduced sweet corn N accumulation compared with all other treatments, being 44% and 36% lower than control treatment value of 117 kg.N.ha^{-1}. At Site-A, the lupin, mustard/lupin and mustard treatment effects on sweet corn N accumulation were not different from that of the control treatment at final harvest. However, at Site-B the lupin and mustard/lupin mix treatments did produce sweet corn N accumulation levels significantly higher than the control treatment; being 21% and 18% higher than the control value of 102 kg.N.ha^{-1}, respectively.

Compared to the control treatment sweet corn yield (17.3 t ha^{-1} averaged over both sites), none of the four green manure treatments improved sweet corn yield even though the lupin and mustard/lupin mix treatments both increased soil N availability and sweet corn N accumulation. Soil moisture limitations probably restricted yield potentials. However, the ryegrass treatment detrimentally affected sweet corn yields at both sites. When compared to the control treatment reductions of 64% and 48% at Site-A and Site-B, respectively, were measured.

Soil mineral N (0-150 mm) tested early in the sweet corn growing season gave a better relationship with sweet corn N accumulation and yield compared with the incubation tests used. Short-term soil incubation tests, conducted under aerobic and anaerobic conditions, were not useful as indicators of net N mineralisation as they did not relate well to actual soil N mineralisation or crop response.

Although both the lupin and the mustard/lupin mix treatments had similar effects on soil N availability and sweet corn N accumulation, of the two the lupin treatment achieved a higher level of estimated N fixation. On average the estimated N fixation in the lupin treatment (98 kg N ha^{-1} averaged over both sites) was higher than N losses in harvested sweet corn ears (77 kg N ha^{-1} averaged over both sites). This positive N balance would help compensate for other possible N losses from the soil-plant system (ie. ammonia volatilisation or nitrate leaching).

Overall, the lupin green manure treatment appears be the best crop in terms of improving short-term N availability for the subsequent sweet corn crop and for maintaining an N balance in the soil–plant system. But ultimately, the benefit of lupin as a green manure crop will also depend on environmental conditions and management practices.

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