Sustaining Maize Production in the Democratic People's Republic of Korea (DPRK)

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Abstract

Since the 1990's, maize yields in the DPRK have fallen from 6-8 t/ha to 3-4 t/ha contributing to severe food shortage. In the absence of readily available fertiliser N, maize yield response to N-fixing green manure vetch, and run-off and erosion response to surface retention of crop stubbles, were measured over three seasons at two sites in the major grain producing region of DPRK. Overall mean vetch yield, 9.7 FW t/ha boosted maize yield by an overall average of 0.9 t/ha, equivalent to urea applied at 60 kgN/ha. Autumn-sown hairy vetch was more productive and effective than spring-sown common vetch. Inter-row vetch reduced yields at one site. Direct drilling maize into semi-permanent flat beds and retaining maize and vetch stubbles reduced run-off by 47-66% and soil loss by 58-74% as compared with traditional practice.

Media summary

Adopting legumes and soil conservation practices into cropping systems in the DPRK will sustain an improvement in maize yield and hence in food security.

Key Words

Cropping systems, legume, corn, soil conservation

Introduction

Severe food shortage in the Democratic People's Republic of Korea (DPRK) is a result of substantial declines in the yields of staple cereal crops, for example a 50% reduction in the yield of maize from 6-8 t/ha a decade or so ago (Michalk and Mueller 2003). Reduced use of fertiliser due to economic constraints (Ireson 2006) and over-cultivation of hill soils, exposing them to chronic soil loss, have contributed significantly to the yield reduction. Restoration of cereal yields is a national priority. However, procuring the annual amount of N fertiliser required to restore maize yields to past levels is prohibitive economically, is tenuous if sourced through international aid programs, and will do little to protect soil from intense summer rainfall. Legumes grown over winter or in early spring may improve soil fertility and increase the yields of subsequent cereal crops (Frey et al. 1985; Evans et al. 1991), in this case summer-grown maize. Direct-drill crop establishment into stubble may reduce the risk of erosion and improve yield by reducing rainfall-run-off (Moody et al. 1963, Blevins et al.

1971). These strategies were applied to maize cropping systems in the DPRK to increase yield and reduce run-off and soil loss.

Methods

Field trials were conducted at two sites. At each site, a crop rotation trial and a soil conservation trial were established. The crop rotation trial involved summer maize rotated either with autumn-sown hairy vetch (*Vicia villosa*) or spring-sown vetch (*V. sativa*), (collectively the phase vetch treatments). In other treatments vetch was sown between rows of maize (inter-row vetch) in combination with the phase vetch treatments. The control rotation comprised the traditional maize-fallow within-year rotation.The rotations were continued for three seasons with annual vetch and maize grain yields recorded. The soil conservation trial involved summer maize rotated with autumn-sown vetch. The soil conservation treatments included maize established into semi-permanent flat beds without and with maize stubble retention (2 t/ha), and the latter without and with vetch stubble retention (t/ha according to season). The control treatment comprised traditional maize practice, with the crop established on ridges formed in annually cultivated, stubble-free soil. Land slope varied 5-11%. Rainfall run-off and soil loss were monitored during several significant summer rainfall events, from 20 mm to 134 mm.

Results

The mean yield of the phase vetch treatments was variable with site and season, generally greater with autumn-sown vetch, and greater with inclusion of inter-row vetch (Table 1).

Table 1. Yields of vetch (FW t/ha). Values in a row, without a common letter, are significantly different (P=0.05).

Hyongsan			UnSong		
2002/03	2003/04	2004/05	2002/03	2003/04	2004/05
9.9b	8.2b	6.0a	11.8c	19.4d	8.2b
Spring-sown	Spring-sown + inter-row	Autumn-sown	Autumn-sown + inter-row		
6.9a	10.0b	9.2b	14.7d		

Effects of vetch on maize yield were investigated in terms of the cumulative response in maize yield as a function of the cumulative addition of vetch green manure. This approach was taken because maize yield response in any given season is an integral of vetch effects in all prior seasons. All site and treatment variation in vetch yield, about the means above, was used in this analysis. At each site, cumulative yield response was a positive linear function of the cumulative addition of vetch (Fig.1), with the cumulative gain in maize yield averaging 77 kg / FW t of vetch. Over the three seasons the accumulated maximal increase in maize yield was 4-5 t/ha, with an accumulated vetch addition of 50-60 FWt/ha.

The effect of three different soil conservation treatments on the relationship between soil loss and rainfall volume at UnSong is shown in Fig. 2. The order of the treatment differences was consistent with their effects on rainfall run-off (data not shown). Combining maize and vetch stubbles and direct-drilling maize into flat beds had the greatest effect in reducing soil loss (and rainfall run-off), and this system was more resilient than the traditional system to the effects of higher rainfall on soil erosion. The combined stubbles reduced soil loss by up to 58-74% as compared with the loss with traditional maize practice.

Fig. 1. Influence of vetch green manure on the yield of maize at the two experimental sites. The correlation at the treatment mean level (solid symbols) was r = 0.94. The dashed plots indicate the trend for the complete data range.

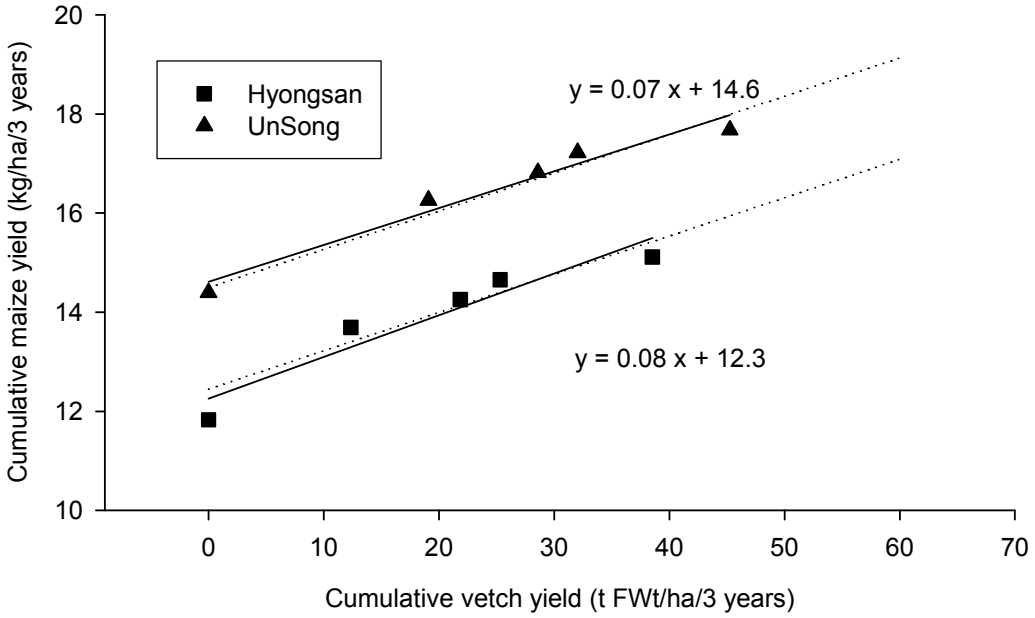
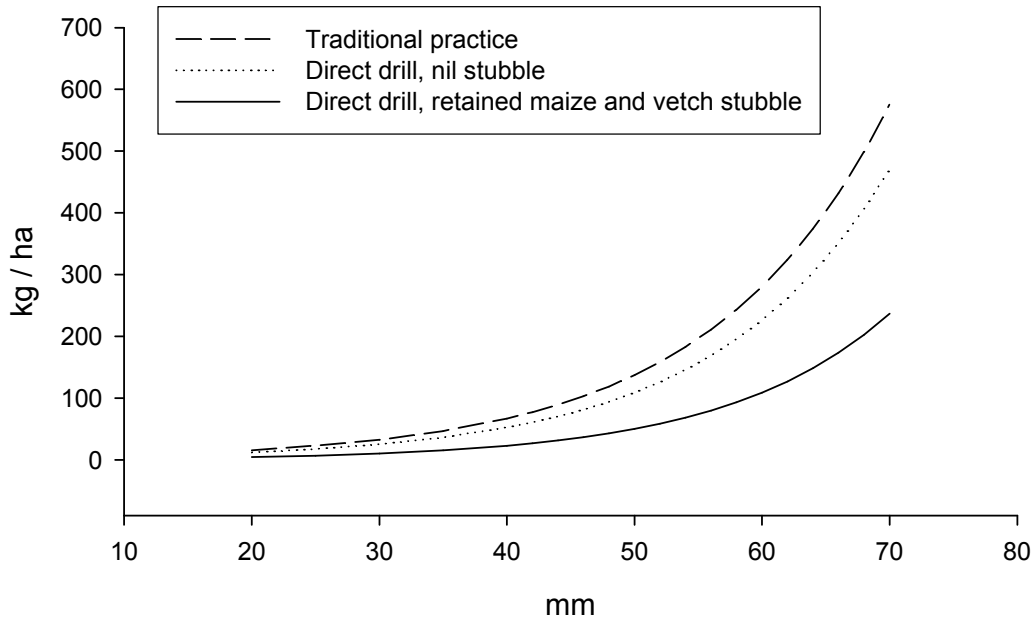


Fig. 2. Modelled relationships between soil loss and rainfall developed from twelve observations at UnSong over 2003-2005. The model was significant at P < 0.001.



Conclusion

A progressive increase in maize yield can be anticipated with the regular inclusion of a vetch green manure between crops of maize. Initially the rate of increase will be greater with more vetch manure and this rate can be favoured by autumn-sowing a winter-tolerant vetch. Including vetch as an inter-row with maize is more problematic. Whilst increasing the total amount of vetch manured, it significantly reduced (up to 10%, $P<0.05$) maize yield at one of the sites (data not included), presumably by competing with maize for water. Direct-drilling maize into flat beds and retaining surface maize and vetch stubbles will slow the rate of soil loss substantially. However, to bring this loss closer to nil, more of the maize stubble may need to be retained. It also remains to be seen whether surface retained vetch stubble will have the same impact on maize yield as when it was incorporated into soil.

References

Blevins RL, Cook D, Phillips SH, Phillips RE. 1971. Influence of no-tillage on soil moisture. Agron. J. 63: 593-596.

Evans J, Fettell NA, Coventry DR, O'Connor GE, Walsgott DN, Mahoney J, Armstrong EL. 1991. Wheat response after temperate crop legumes in south-eastern Australia. Aust. J. Agric. Res. 41: 347-359.

Frye WW, Smith WG, Williams RJ. 1985. Economics of winter cover crops as a source of nitrogen for no-till corn. J. Soil Water Cons. 40: 246-249.

Ireson R. 2006. Food Security in Norh Korea: Designing Realistic Possibilities. Proc. FAO Meeting (May 2006), Beijing, 29 pages.

Michalk M, Mueller HP. 2003. Strategies to improve cropland soils in North Korea using pasture leys. Agric. Ecosyst. And Environ. 95: 185-202

Moody JE, Jones JN (Jr), Lillard JH. 1963. Influence of straw mulch on soil moisture, soil temperature, and growth of corn. Soil Sci. Soc. Am. Proc. 27: 700-703.