Darwin Initiative Main/Post/D+ Project Half Year Report

(due 31st October 2017)

Project reference	22-012 ref App2701
Project title	Harnessing agricultural ecosystem biodiversity for bean production and food security.
Country(ies)/territory(ies)	Tanzania, Malawi and UK.
Lead organisation	Royal Botanic Gardens, Kew
Partner(s)	Nelson Mandela African Institution of Sci. & Technology, Arusha. Natural Resources Institute, University of Greenwich. Lilongwe University of Agriculture and Natural Resources. Charles Sturt University, Orange, Australia.
Project leader	*Prof Philip C Stevenson*
Report date and number (e.g., HYR3)	*31 Oct 2017 HYR3*
Project website/blog/social media etc.	*Web site. http://agriculturalecosystems.org* *Project Twitter from @chickpeaman and @SEJArnold*

1. Outline progress over the last 6 months (April – Sept) against the agreed baseline timetable for the project (if your project has started less than 6 months ago, please report on the period since start up to end September).

Output 1. Ecosystems & plant species that are habitats for key natural enemies identified.

Plant surveys were undertaken across Malawi field sites to compare with those in Tanzania. Far fewer and much less complex plant invertebrate interaction networks were recorded during these surveys and in the least botanically diverse landscapes only 3 plant species occurred with field margin interactions as compared to around 30 species in Tanzania. Species identified through the field margin survey differed to those identified in Tanzania with only a few species occurring in both including *Richardia scabra*. In the least botanically diverse landscapes the only non-cultivated indigenous species was *Oxygonum sinuatum*; the most abundant plant species across the experimental zone in Malawi. Aerial photographs helped illustrate how the landscape is associated with plant insect interactions. Figure 1 below shows the interaction networks for plants and natural enemies of pests in botanically diverse landscapes and more intensive agricultural landscapes near Lilongwe (Malawi) with very low plant diversity. These data show contrasting effects on the diversity of beneficial insects under different landscapes which can impact service delivery for both pollination and natural pest regulation. For example, Malawian fields with any sort of semi-natural margin contained 2.5 times more plant species than fields with no set-aside margin area at all, and supported twice as many total plant-insect interactions. The biodiverse margin plant-natural enemy network exhibited more specialization (H2 index of 0.362 compared to 0.288), and a higher complexity (linkage density; 7.833 compared to 5.566). The diverse margin network was also more robust (0.8897 compared to 0.7960). Figure 2 shows the penalty farmers with poor field margins suffer in Malawi: crops grown in fields with no or minimal margins suffer significantly more damage (F = 9.112, p = 0.003) and have fewer undamaged beans around the edges of their fields (F = 6.579, p = 0.011). This is particularly important in smallholder systems where fields are small so are vulnerable to edge effects. However, it is not known what distance influence specific field margin plants have in supporting the food and refuge needs of key beneficial insects. An additional indication of the benefit derived from diverse insect pollinator populations from our prior data is illustrated by the benefit of a 49.8% increase in yield in open-pollinated plants relative to bagged bean plants as described below.

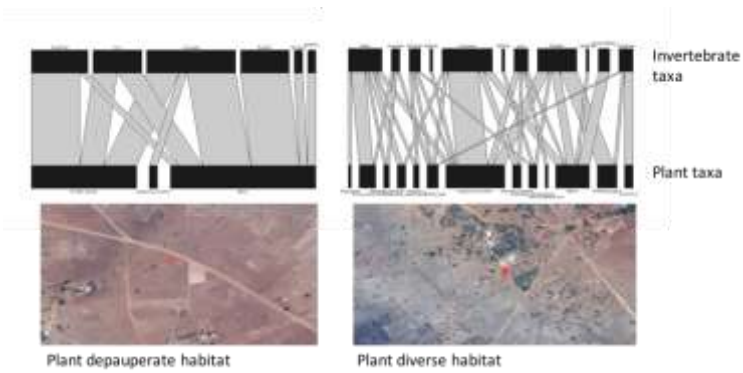

Fig. 1 Plant species recorded as visited by insects during the survey, across all sites, zones and seasons

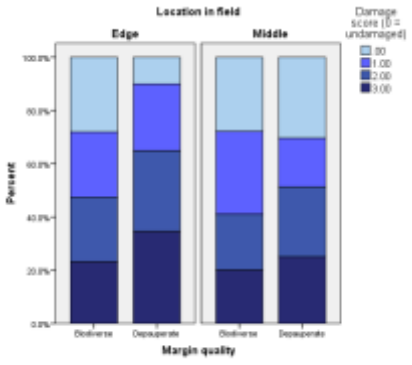

Fig. 2 Yield penalty in field margin suffered by farmers with different margin quality

Output 2: Key invertebrate pollinators of beans and their key habitat established.

Experimental assessment of the contribution of pollination to crop yield was evaluated using bagging experiments at field sites in Himo and Moshi in Tanzania. In these experiments, randomly selected bean plants were bagged with a mesh that prevented visitation by potentially pollinating invertebrates and the seed set was measured and compared to hand pollinated flowers (bagged afterwards) and unbagged flowers to which pollinating insects were permitted to visit. Overall the benefit to yield afforded by pollinating insects on bean plant yields as measured by pods per plant and beans per pod in Tanzania across 4 sites ranged from 40 to 100% (i.e., the absence of pollinating insects could half yield). Thus, the potential yield gap in landscapes that are depauperate in pollinators is substantial and greater than originally predicted in the proposal. However, because there was no significant difference in the seed set between open pollinated and hand pollinated this suggests that in the agricultural landscapes of Mount Kilimanjaro there is no pollination deficit. In considering the plant insect interaction network above in Figure 1 is typical for Malawi bagging experiments to determine if plant depauperate farmland leads to pollination deficit in Malawi have also been undertaken but the data is still being collected.

Output 3: Capacity of 400 lead farmers increased by information and guidance on exploiting and maintaining agricultural biodiversity for improved crop yield.

Baseline data was recorded for >200 farmers participating in the project action in Malawi and data is being analysed by the project economist. This means the number of farmers forming part of the pre- and post-intervention survey will be significantly greater than the number originally proposed. An information leaflet has been produced and is being translated into local languages in preparation for distribution to 6000+ farmers as part of planned training activities in January 2018 in Malawi and Tanzania.

Fig 3. Information leaflet in English (will be translated into Kiswahili and Chewa) describing the importance and role of some key beneficial insects from bean cropping systems

Output 4: Field margin plant species that support beneficial insects evaluated for their biological activity against pest insect species of beans and effects on beneficial insects determined.

We have continued to evaluate the biological activity of pesticidal plants that provide field margin food and refuge for beneficial insects primarily through farmer field trials among around 100 farmers. Insect abundance on bean crops treated with pesticide plant extracts measured by a Farmer Research Network in Mitundu, Malawi suggest that there are major hurdles to evaluating inputs and innovation solely through farmer assessment as the variation in yields were too great to show significant differences in effects. A reassessment of the data by context through collation of information about participating farmers will establish if there are underlying parameters that can correct for these anomalies. In station

trials extracts of six invasive weed species suppressed key insect pests of common bean. A commercial synthetic was the most effective in reducing insect abundance and damage but harvested bean yield was comparable between the synthetic and weed extract treatments. The extracts had comparatively lower impacts on key arthropod predators which may have contributed to crop yields. Small holder farmers accurately ranked the efficacy of the treatments with respect to pest damage and overall yield obtained. This work is being published in *Industrial Crops and Products.*

Output 5: Post-graduates trained in conducting biodiversity surveys and carrying out field and laboratory based research.

MSc students (X3) under supervision of Kew, NRI & local partners registered at NM-AIST set up experiments to run from March. These were monitored through to harvest in June/July in this half year and evaluated the contribution of 5 specific key field margin plants to ecosystems service delivery for pollination and natural enemies of pests on 5 X 5m plots comprising single species field margin plantings. Students defended research proposals through viva in the previous semester through the university process and research data collection is complete with data analysis being done. 2 PhD students who have undergone comprehensive field training in monitoring and evaluating plant and invertebrate assemblage and interactions of plants and insects making collections and progress towards an institute reference collection. The students have continued to collect data for their PhD and are preparing to travel for a 3 month study visit to Charles Sturt University (Australia) for further training.

2a. Give details of any notable problems or unexpected developments/lessons learnt that the project has encountered over the last 6 months. Explain what impact these could have on the project and whether the changes will affect the budget and timetable of project activities.

We were held up by the slow progress of recruiting PhD students at the project outset but now both are up to speed and we have been able to undertake a second season-long survey of insect plant interactions in field margins based on a complete survey of plant species and invertebrate functional groups. Fall army worm invasion led to many farmers resorting to commercial synthetics. Can pesticidal plants work quickly enough?

2b. Have any of these issues been discussed with LTS International and if so, have changes been made to the original agreement?

Discussed with LTS:	Yes/~~No~~
Formal change request submitted:	~~Yes~~/No
Received confirmation of change acceptance	Yes/~~No~~

3a. Do you currently expect to have any significant (e.g., more than £5,000) underspend in your budget for this year?

Yes ☐ **No** ☒ Estimated underspend: £

3b. If yes, then you need to consider your project budget needs carefully.

4. Are there any other issues you wish to raise relating to the project or to Darwin's management, monitoring, or financial procedures?

No

If you were asked to provide a response to this year's annual report review with your next half year report, please attach your response to this document. Additionally, if you were funded under R23 and asked to provide further information by your first half year report, please attach your response as a separate document.
Please note: Any planned modifications to your project schedule/workplan can be discussed in this report but should also be raised with LTS International through a Change Request.
Please send your **completed report by email** to Eilidh Young at Darwin-Projects@ltsi.co.uk . The report should be between 2-3 pages maximum. **Please state your project reference number in the header of your email message e.g. Subject: 22-035 Darwin Half Year Report**