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Effects of organic versus conventional fertilizers on insect pests, natural enemies and yield of *Phaseolus vulgaris*

J. Karungi [a,*], B. Ekbom [b], S. Kyamanywa [a]

[a] *Crop Science Department, Makerere University, P.O. Box 7062, Kampala, Uganda*
[b] *Department of Entomology, Swedish University of Agricultural Sciences, P.O. Box 7044, S-750 07 Uppsala, Sweden*

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Abstract

Field studies were conducted during 2003 and 2004 for three consecutive growing seasons. The treatments were (1) market crop wastes (MCW) compost incorporated in the soil, (2) un-composted MCW incorporated in the soil, (3) un-composted MCW applied as a surface mulch, (4) a conventional chemical fertilizer (NPK) incorporated in the soil, and (5) the untreated control. Response variables recorded included plant height and width, leaf area, tissue nitrogen content, nodulation; occurrence of *Aphis fabae, Maruca vitrata* and the associated natural enemies; and grain yield. Results indicated that significant differences in plant attributes and yield were only detected in the second and subsequent season of the crop or when weather conditions were stressful. For the insect pests, it was only *A. fabae* infestation that varied among treatments with MCW amended plants sustaining higher infestations than NPK and the untreated control, a trend that held for all the seasons. Natural enemy occurrence followed the trend of *A. fabae* infestation. After the first and subsequent harvests, more P, K, Ca, and Mg were extracted from the soil from MCW plots than NPK plots. The study indicated that yields accruing from MCW amended plots were comparable and sometimes even higher than those from NPK despite the higher *A. fabae* infestation of the former.

Keywords: *Aphis fabae*; *Maruca vitrata*; *Phaseolus vulgaris*; Soil fertility amendments

1. Introduction

Despite the great importance of *Phaseolus vulgaris* L. in East Africa, yields are generally low (<500 kg ha^{-1}) compared to yield potentials of between 1000 and 4000 kg ha^{-1} (Malyego, 1991). Beans in East Africa often suffer from nutrient stress and have been shown to respond positively to soil fertility amendments (Byabagambi et al., 1999). Because gains from nitrogen fixation have proven limited, monoculture beans are often fertilized on farms that can afford to do so at a rate of about 60 kg N ha^{-1}in order to improve yields (Henson and Bliss, 1991).

On resource-poor farms, which are in the majority in Africa, there is limited addition of nutrients from outside the system; the only major source of available plant nutrients is through mineralisation of soil organic matter from decomposing residues. Consequently, soil fertility is declining because nutrients removed at harvest are not being replaced, in part, because inorganic fertilizers are neither available nor affordable to smallholders (Smaling, 1993), and also because most of the produce from farms is transported to the urban markets in raw form. The peels/haulms and other non-edible parts of the plants are subsequently dumped in the markets environs causing a problem with market crop waste (MCW) accumulation (Sendawula et al., 1997). There is, therefore, a need to develop innovative and sustainable ways of managing soil fertility problems within the smallholder sector, primarily, returning of organic wastes back to the land.

However, before recommendations are made to farmers about the utilisation of the MCW as a soil fertility amendment, several questions need to be answered first.

* Corresponding author. Tel.: +256 41 53 35 80; fax: +256 41 53 16 41.
E-mail addresses: jkarungi@agric.mak.ac.ug, jkarungitumu@yahoo.com (J. Karungi).

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(i) Can utilisation of MCW amendments have an effect on the population development of insect pests in the crop? (ii) Can the MCW amendments promote the abundance of natural enemies attacking the pests? (iii) Can the plants derive enough nutrition from the MCW amendments so as to produce good yields? (iv) Is it profitable for the farmer? This study was aimed at finding the answers to the above questions. The goal was to understand implications of utilisation of MCW in integrated pest management and soil nutrient management.

2. Materials and methods

The study was carried out at the Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) (0°28′N; 32°27′E; 1200 m a.s.l) in Uganda in 2003 and 2004. The site's soils were oxisols with a pH 5.6. The area had a bimodal rainfall pattern with April–May and October–November as the wettest months. The mean daily maximum and minimum temperatures of the area were about 27 and 17 °C, respectively. Season 1 of the experiment was from September to November in 2003; season 2 from April to June 2004, and season 3 from September to November 2004. Seasons 1 and 3 were characterised by regular rainfall showers but season 2 was very hot and dry with very few occasional rain showers. Variety K132 of *P. vulgaris* was obtained from the Kawanda Seed Project of the National Agricultural Research Organisation. This variety was selected because it is popular among farmers and is of moderate pest resistance. MCW were obtained from garbage skips in the markets of Seeta, a suburb of Kampala. The facilities of a local Non-Governmental Organisation (NGO), Talent Call, in the town suburbs were used for composting the MCW using the windrow technique (Gordon et al., 2001)

A randomised complete block design was used with the following treatments (1) MCW compost incorporated in the soil, (2) un-composted MCW incorporated in the soil, (3) un-composted MCW applied as surface mulch, (4) a conventional chemical fertilizer (NPK) incorporated in the soil, and (5) the untreated control. The amendments were applied each growing season. The organic amendments were applied at a rate of 12 t ha^{-1} dry weight, whereas NPK was applied at a rate of 70 kg N ha^{-1}, 50 kg P ha^{-1}, and 50 kg K ha^{-1}. These rates were within the range recommended for resource-poor farmers. Each treatment was planted in plots measuring 10 m × 5 m with 2 m alleys in between and replicated four times. Beans were directly sown in the field at a spacing of 0.5 m × 0.2 m. Three seeds were sown per hole but were later thinned to two seedlings per hill at 4 weeks after emergence. The experimental plots were kept weed free using a hand hoe. The experiment was maintained under rain-fed conditions in seasons 1 and 3 but because of the unreliable rain in season 2, water was applied (sprinkler system) twice a week at the flowering and pod filling stage. The treatments were replanted in the same plots used in season 1, during subsequent seasons.

The physical growth attributes of plant height, width, and leaf area were assessed on 10 plants per plot randomly selected following the two diagonals of each plot. Leaf area was determined for the youngest fully expanded leaf and was estimated by multiplying leaf width by length. The data for physical attributes was collected weekly from 14 days after emergence (DAE) until flower bud formation. For nitrogen content determination, five plants were randomly uprooted per plot at 30 DAE; the lower portions (collar and roots) were cut off and used for nodules counts. The shoots were dried to a constant weight, ground to a homogeneous powder, and then analysed using the Kjeldahl method (AOAC, 1991). Nodulation levels were assessed in season 3 by counting the number of nodules on all the roots of the five uprooted plants.

2.1. Samplings

Insects of two taxa, *Aphis fabae* Scopoli (Homoptera: Aphididae) and *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae) representing suckers and chewers, respectively, were selected. Sampling for *A. fabae* was done weekly from 14 DAE to pod formation by randomly selecting 10 plants per plot along the two diagonals. In season 1, the mean *A. fabae* infestation per plant was rated on a scale of 1–6 where 1 = no aphids; 2 = 1–9; 3 = 10–29; 4 = 30–59; 5 = 60–99; 6 ≥ 100 aphids in subsequent seasons, both the rating and the individual insect counts were used. Stems, upper and lower surfaces of all the leaves of the selected plants were carefully examined for aphids. Both the immatures and adults were counted. The number of colonising alates was also recorded on 10 plants per plot at 10 DAE. *M. vitrata* occurrence was estimated by noting the number of plants with *M. vitrata* pod damage per 10 randomly selected plants per plot at 50 DAE.

Natural enemies: (i) Assessment of number of aphids parasitized was carried out on the same plants used for estimating aphid abundance. Percentage parasitism was estimated using mummy to aphid ratios following the method used by Kalule and Wright (2002), i.e., percentage parasitism = $(m/[a + m]) \times 100$ where: m is the total number of mummies and a is the number of live aphids. In order to avoid the problem of mummy accumulation over time, only the mummies without emergence holes (full mummies) were recorded. (ii) Assessment of predator abundance was also done on the same plants used to estimate aphid abundance. Direct observations were used to study the occurrence of ladybird beetles (Coleoptera: Coccinellidae), syrphid flies (Diptera: Syrphidae) and spiders (Arachnida: Araneae). The sampling procedures indicated above for predators continued through the plant growth stages when *M. vitrata* attacked the crop.

Yield parameters: All the plants from each plot were threshed to separate the grains from the haulms, and were sorted until only clean grains (marketable) remained. The