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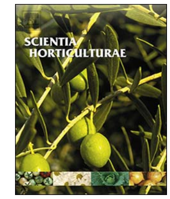

Effect of organic and inorganic nutrient sources on the yield of selected tropical vegetables

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ABSTRACT

Results from different experimental studies that compared organic and inorganic nutrient sources on yield of tropical vegetables were subjected to meta-analysis to quantify the overall effect of nutrients on crop yield. The selected studies reported organic to conventional yield comparisons on ten tropical vegetable crops viz. amaranthus (*Amaranthus tricolor* L.), brinjal (*Solanum melongena* L.), chilli (*Capsicum annuum* L.), okra (*Abelmoschus esculentus* (L.) Moench), tomato (*Solanum lycopersicon* L.), bitter gourd (*Momordica charantia* L.), coleus (*Solenostemon rotundifolius* (L.) Codd.), cowpea (*Vigna unguiculata* (L.) Walp), snake gourd (*Trichosanthes anguina* L.), and cucumber (*Cucumis sativus* L.). Random effect model of the statistical programming software Comprehensive Meta Analysis Version 2 was used in the analysis. Mean yield was used as the compared outcome and standard mean difference (SMD) between the treatment and control yield was used as the effect size metric. Forest plot results indicated the combined effect of the data from the selected studies of tropical region over a period of thirty years (1985–2015). The overall standard mean difference (SMD) of yields between organic and inorganic sources of nutrition showed significant increase in crop yield under organic nutritional sources. However, meta-analysis that combined the overall effect estimate of standard mean difference of yield between nutrition with organic sources and conventional recommended integrated POP nutrition indicated no significant difference in yields. It could also be inferred that the effect of organic nutrition was significant only when the dosage was considerably enhanced or supplemented with different sources of manures. The long term sustainability of organic nutrition in vegetable crops depended on the quantity and quality of organic manures applied, crop yield, quality and price of the produce.

1. Introduction

Vegetables form an indispensable part of daily diet in countries like India where there is a predominant vegetarian population. Its importance both as a nutritional security component in health diets and as a good source of essential minerals and vitamins is also on the rise, along with the growing public awareness about the negative health impacts of indiscriminate use of agro-chemicals in crop production. The latter have caused an increase in demand for organically grown vegetables that are reputed to be free of any residual contaminants causing health hazards (Willer and Kilcher, 2011). But large scale conversion to organic production has been debated for its effectiveness in meeting production goals. Complete organic production warrants the use of organic sources and botanicals in plant nutrition, plant protection and all other related crop production practices. This prohibits the use of common mineral fertilizers that include all nitrogenous and potassium fertilizers except sulphate of potash and non-mineral phosphatic fertilizer sources like super phosphate. These mineral sources are replaced in organic vegetable production protocols with regular supplements of organic nutrient sources in the forms of manures, compost, green leaf and other bio-nutrient sources. Prophylactic and preventive methods of plant protection involving botanical/animal/microbial products and management strategies have also gained prominence. These differences in production protocols between organic and conventional methods that involve agro-chemical use are perceived to affect the yield and quality of the produce as well as natural resource conservation. The results are in favour of organic production in terms of health and environmental risks but conclusive supports on production efficiency are deficient. Many scientific studies on comparing different concentrations of nutritionally relevant organic and inorganic nutrient

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sources on yield are available, but the results have been contradictory. Researchers have seldom attempted to synthesize the results from various studies in order to provide with a conclusive organic policy information (Seufert et al., 2012). A synthesis has been attempted in the present study, focused on quantifying the overall effect of different experimental studies that compared organic and inorganic nutrient sources on yield of tropical vegetables.

2. Materials and methods

Organic vegetable production has been operationally defined for the study as the exclusive use of biological sources for crop nutrition whereas use of any synthetic chemical source in crop nutrition was included under conventional vegetable production. All other farming practices from seed to harvest in both cases were followed as per the crop recommendations in Package of Practices of the period of study.

2.1. Literature search

Both peer reviewed literature from journals and Post Graduate (PG) research reports of M.Sc. and Ph.D. students of Kerala Agricultural University (KAU), a leading institute in agricultural research and education in South India was purposively selected for the study. Library database of the KAU was accessed at http://library.kau.in/cgi-bin/koha/opac and Google scholar was used to identify the journal publications on organic vegetables in English from similar tropical regions. The search terms used to identify the web and library sources were '(organic* or ecologic* or biodynamic*) and (conventional* or integrated) and (vegetable* or tropical*)'.

2.2. Selection of review period

The titles were checked, to extract 278 studies reporting original results of comparisons on the effect of different organic nutrient sources on vegetable yield, under organic and conventional methods of nutrition. Also title catalogue searches of PG research works of the KAU library were used to extract 55 additional references in the area. These together accounted for a total of 333 data sources from primary experimental studies for the review. The search results included studies from as early as 1955, but the number of studies prior to 1980 was very few compared to post 1980 period. The six titles with suitable data sets identified for the period prior to 1980 were subsequently rejected as the small number minimized any potential bias from using time frame in the selection criterion and full access of contents was not available. The review results indicated an increase in the number of studies related to organic farming in the post 1980 period and hence the period of study has been fixed as thirty years between 1985 and 2015.

2.3. Inclusion criteria

Inclusion criteria recommendations given by Koricheva and Gurevitch (2014) were used to identify suitable studies for meta analysis. Presence of duplicate data and crops not related to the tropics was also used as criteria for selection of studies. The specific inclusion criteria used for the selection of studies to draw yield data for analysis are enlisted below.

- appropriateness of experimental treatments that discriminated the effects of fertilization from other farming practices,
- availability of nutrient content data of different inorganic fertilizer forms and organic products applied in compared systems,
- fertilization method that followed uniform basal and split applications as per recommendations,
- homogeneity of varieties used tropical locations of study.

Accordingly data sets that were repetitions (21 no.), unrelated data sets related to cool season vegetables grown in tropics (161 no.) and data sets related to non- nutritional components of organic farming (93 no.) were excluded from the study. Thus the study was limited to 39 research studies that met the inclusion criteria representing study sites from tropical countries of Asia and Africa. This included 16 PG research studies conducted at the KAU research farms located in three major agroclimatic zones of Kerala viz. southern zone, central zone and northern zone and the rest from the published research journals. The selected studies reported organic to conventional yield comparisons on ten tropical vegetable crops viz. amaranthus (*Amaranthus tricolor* L.), brinjal (*Solanum melongena* L.), chilli (*Capsicum annuum* L.), okra (*Abelmoschus esculentus* (L.) Moench), tomato (*Solanum lycopersicon* L.), bitter gourd (*Momordica charantia* L.), coleus (*Solenostemon rotundifolius* (L.) Codd.), cowpea (*Vigna unguiculata* (L.) Walp), snake gourd (*Trichosanthes anguina* L.), and cucumber (*Cucumis sativus* L.).

2.4. Estimation of publication bias

Though the present study relied equally on the available body of published studies and unpublished Post Graduate research reports of KAU, any chance of publication bias in interpreting the outcomes of meta-analysis was evaluated using a funnel plot graph (Fig. 1). The funnel plot graph of standard error on the *y* axis plotted against the measure of effect on the *x* axis (standard difference in means). The plot was not skewed and resembled a symmetrical (inverted) funnel which indicated the absence of possible publication bias. Another potential advantage of using standard errors was that in the absence of both biases and heterogeneity, 95% of studies fell within the triangular region (Fig. 1).

2.5. Data exclusion and information extraction

Studies that reported comparable yield data on temporal and spatial scale in organic and conventional nutritional treatments were included for the final analysis. If data from the same study was reported in several papers, the data was included only once from the source that reported it in greatest detail. Data sets of studies that compared organic and no nutrient regimes and integrated combinations in various proportions of Package of Practices – crops (POP) recommendation were excluded from the present analysis. Accordingly data were extracted from two types of comparative studies: (1) field trials of organic nutrition in different proportions of recommended doses compared to recommended doses of nutrition as inorganic fertilizers alone and (2) studies that compared organic manures in different proportions of recommended doses with recommended integrated doses of organic and inorganic nutrient sources as per POP-crops recommendations. These comparisons assumed significance as they were the two

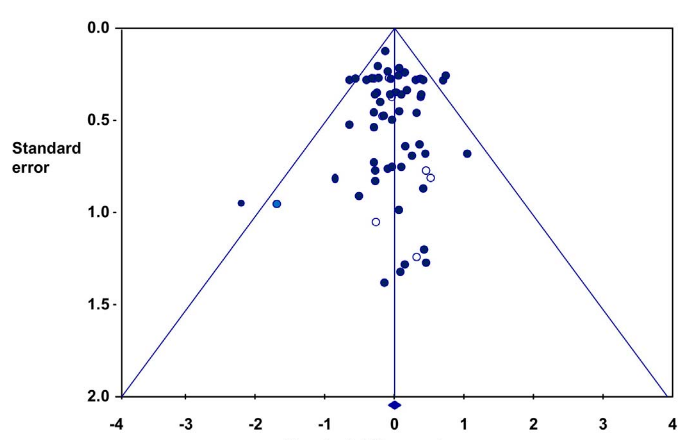

Fig. 1. Funnel plot of standard error by standard difference in means.