Effect of Some Organic Insecticides on the Yield and Quality of Field- grown Tomatoes (*Solanumlycopersicum* L.)

By

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DEDICATION

I dedicate this dissertation

To

My mother's spirit, my father, my sisters and my lovely brother,

my husband and my sweet daughter,

my friends

and my teachers.
ACKNOWLEDGEMENT

First of all I owe great thanks to Allah, the almighty God for keeping me healthy and able to do this work.

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Effect of Some Organic Insecticides on the Yield and Quality of Field-grown Tomatoes (Solanum lycopersicum L.)

M.Sc. Horticulture

Maaza Mohammed Yosef Mahajop

Abstract: The objective of this research was to evaluate the vegetative and reproductive parameters of field-grown tomato in response to organic insecticides. An experiment was carried out at the orchards of the Department of Horticulture, Faculty of Agriculture, University of Khartoum, Sudan during the period November 2011 - March 2012. The layout of the experiment was randomized complete block design with four replicates. Treatments were three organic natural insecticides, namely Vertamic, ‘Neem’ seedkernels’ water extract, Argelleaves’ water extract and the control (no insecticide). Organic fertilization using chicken manure and plastic mulching for weeds control were used in all treatments. Seedlings of tomato plant were transplanted on 22 November 2011, and the experiment continued for 17 weeks. Starting from 6-17 weeks after transplanting (WAT), data were collected on number of branches per plant, number of trusses per plant, number of total flower buds per plant, marketable and unmarketable yield. At the end of the experiment average fresh and dry weights per plant were recorded. Results indicated that number of branches/plant, number of trusses/plant, number of total flower buds/plant were not significantly different among treatments during the period 6-14 WAT. However, total and marketable yields were significantly (P<0.05) different. The unmarketable yield showed no significant difference during the period 10-17 WAT. Also fresh and dry weight per plant showed no significant difference among treatments. In conclusion, use of the organic insecticide Vertamic gave higher yield (19.4 t/ha) than the other
two organic insecticide, control as well as the conventional tomato yield in Khartoum State (13.37) t/ha (reports Ministry of Khartoum State 2006-2007-2008). Further investigations need to be carried out to verify the above results.
أثر بعض المبيدات الحشرية العضوية علي إنتاجية ونوعية الطماطم (Solanum lycopersicum L.) في الحقل

ماجستير البساتين

معزة محمد يوسف محجوب

CHAPTER ONE
INTRODUCTION

Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Generally organic agriculture means anti-synthetic production (fertilizers and pesticides … et). Also it works in harmony with nature.

Organic farming was the original type of agriculture, and has been practiced for thousands of years. After the industrial revolution had introduced inorganic methods, some of which were not well developed and had serious side effects, an organic movement began in the 1940s as a reaction to agriculture growing reliance on synthetic fertilizers. Artificial fertilizers had been created during the 18th century, initially with superphosphates and then ammonia-based fertilizers mass-produced using the Haber-Bosch process developed during World War I (McConnell, 2003). These early fertilizers were cheap, powerful, and easy to transport in bulk. Similar advances occurred in chemical pesticides in the 1940s, leading to the decade being referred to as the 'pesticide era'. The modern organic movement is a revival movement in the sense that it seeks to restore balance that was lost when technology grew rapidly in the 19th, 20th and 21st centuries.

Since 1990, the market for organic products has grown from next to nothing statistically, reaching $55 billion in 2009 according to Organic
Monitors Organization. This demands have driven a similar increase in organically managed farmlands which have grown over the years 2001-2011 at a compounding annual rate of 8.9% (John, 2011). Approximately 37 million hectares worldwide were farmed organically, representing approximately 0.9% of total world farmland in 2009 (Willer and Kilcher, 2011), and there are almost 1.4 million organic producers.

Consumers are purchasing more and more organic products, and the sales of organic products have increased 20% a year on average since 1990. Organically grown food products typically bring a premium price. Organic farming may therefore be a good alternative for many producers who have identified a market for certified organic goods (UF, 2006).

Today the organic food market is described by industry analysts as the most dynamic and rapidly growing sector of the global food industry. The global market for organic products, once a small scale niche market, reached a value of over 63 billion US $ in 2008. Worldwide, about 37.2 million hectares of agricultural land are certified according to organic standards (AAFC, 2007).

In Sudan old production system till the beginning of the twentieth century was almost fully organic. Modern production system introduced inorganic fertilization and pest control with the establishment of large agricultural schemes of Gazira and Irrigated Pump Schemes along Blue, White and the River Nile mainly for cotton farming. Use of the same chemicals intended for cotton was then practiced with vegetables with more society modernization. More recently mis-use of chemical fertilizers and pesticides became more alarming. The peak of irrational use of chemical has been associated with the introduction of protected agriculture where regulations are missing or blind eyes were turned on them.
There are however, three organic projects under certification. Two certified by organic certification organizations Ecocert certification body at Gadareef and Sennar, and one certified by Organic Products Co. at Northern Korofan which started at 2001. These projects produce the Gum Arabic, Sesame, Roselle, Senna pods and Guar because they have high cash values (FAO, 2001).

As such organic agriculture in Sudan is very recent, it faces many constraints, like absence of regulations, insufficient production knowledge and experience, inadequate training and lack of marketing channels.

Current tomato production in Sudan is around 300,000 tons. Industries utilize only 14% of the designed capacity for paste manufacture since bad handling causes 30-50% losses of produce, requiring that more attention be given to post harvest operations (FAO, 2001).

The objective of this research was to evaluate the vegetative and reproductive response of field grown tomatoes to organic insecticides i.e. Vertamic and water extracts of Argel and Neem.
CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Organic farming was defined by the United States Department of Agriculture (USDA) in 1980 as a system that excludes the use of synthetic fertilizers, pesticides, and growth regulators. Organic farming production systems rely heavily on crop rotations, crop residues, animal manures, legumes, green manures, organic wastes, and mineral-bearing rocks to feed the soil and supply plant nutrients. Insects, weeds, and other pests are managed by mechanical cultivation and cultural, biological, and biorational controls (Diver et al., 1999). Later in 1994 the National Organic Standards Board (NOSB), defined organic agriculture as "an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity". So it is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony (Gold, 2007).

In the 18th century, artificial fertilizer used initially was superphosphates (McConnell, 2003). Then during World War II chemicals produced for warfare, were used for agriculture like ammonium nitrate as a source for nitrogen and DDT for pesticide use. That was simultaneous with the Green Revolution in 1944 which encouraged the development of hybrid plants, chemical control, larg-scale irrigation and heavy mechanizations in agriculture. These series of problematic chemical use, lead many scientists in many countries start research during 1950 to1970 to establish organic agriculture concepts and sustainability of agriculture. Till 1970 the goal of the organic movement was to encourage consumption of locally grown
foods. In 1972, the International Federation of Organic Agriculture Movements (IFOAM) was founded in France and was dedicated to the diffusion and exchange of information on the principles and practices of organic agriculture. After that, around the world, farming and consumer groups began seriously pressuring for government regulations of organic production. This led to legislation and certification standards being enacted through the 1990s and to date (UF, 2006).

Organic agriculture has substantial expansion in many countries over the last years reflecting the increased concern over environmental issues of conventional agriculture. In 2008, the organic land increased in more than 90 countries. Since 1999, the organic agricultural land has trebled. The number of people seeking USDA accreditation to become certified agents increased by more than 130% between 2002 and 2005 (Rawson, 2007). According to IFOAM survey (2010) the global market for certified organic food and drink in 2008 was estimated to be $ 51 billion. More than ninety percent of these organic product revenues were made in the northern hemisphere. Europe accounts for 51% of the global organic food sales; North America for 46%. The volume of the turnover with organic products has trebled since 1999. In 2008, the countries with the highest market shares for organic food were Denmark, followed by Austria and Switzerland. The most popular organic product groups are fresh fruit and vegetables, dairy products and bakery wares. USDA estimates the sales of organic foods rose from $ 6 billion in 2000 to $ 10.4 billion in 2003. The annual rate of market growth since 1990 has remained steady at about 20% (Rawson, 2007).

2.2 Merits

The intensive agriculture system caused many problems for ecosystem and humans. Utilizing huge amounts of chemicals in the farm
fertilizers, herbicides and pesticides resulted in pollution of water sources, soil with low organic matter, destruction of micro-organisms in soil, pest and diseases became more resistant to control. Moreover, these chemicals stay for a long time in the soil then enter the food chain causing health problems (HDRA, 1995). The residues of these chemicals in organic food produce are of significantly lower levels than conventional produce. The report indicates that 13% of organic produce samples vs. 71% of conventional produce samples contained a pesticide residue. That makes organic food as safe to consume as any other kind of food (OFRF, 2011). The high pesticides residues may reduce the fertility of humans and animals and the health of their off-springs (Lampkin, 1990). A study carried out at the University of Denmark has shown that women with higher than average levels of pesticides in their bloodstream have double the risk of breast cancer (Hoyer et al., 2000). Moreover, the nutritive value of organic food is different from conventional food. In Germany many studies found that organic food contained higher levels of minerals. The largest differences were for potassium and iron; but magnesium, calcium, phosphorus and vitamin C levels were also higher in organic vegetables (Shuphan, 1973). Also several studies have found more dry matter (less water) in organically produced food than in non-organically grown produce. This means that there are more nutrients per unit weight of food (Woese et al., 1997). Chemicals used in conventional system leach into the ground water and waterways causing damage to the aquatic ecosystems (MAFF, 1998). Another effect is reducing the abundance of insects, wild plants and seeds and, in turn, in the decline of farmland bird species and making unbalance ecosystem (Aebischer, 1997).

Nearly 30 years from 1981, soil carbon data at Rodale Institute’s Farming Systems Trial (FST) in the U.S. show conclusively that improved
global terrestrial stewardship specifically including regenerative organic agricultural practices can be the most effective currently available strategy for mitigating CO₂ emissions. Current farming practices are not sustainable because they reduce soil carbon. Some Midwestern Europe soils that in the 1950s were composed of up to 20 % carbon are now between 1 and 2 % carbon. The multiple research efforts verify that practical organic agriculture, if practiced on the planet’s 3.5 billion tillable acres, could sequester nearly 40 % of current CO₂ emission. Also before forests and grasslands were converted to fields of agriculture, soil organic matter (SOM) generally composed 6 to 10 % of the soil volume, well over the 1 to 3% levels typical of today’s agricultural field systems. Over 27 years research in greenhouse gave evidence that organically managed soils convert carbon from gas into a food-producing asset, that showed 30 % increase in soil carbon (LaSalle, 2008). All these reasons make organic agriculture a way towards sustainability over the long term effect of agricultural interventions on the agro-ecosystem. It aims to produce food while establishing an ecological balance. (FAO, 2001).

Organic production system include crop rotations which maintain soil fertility and the restricted use of chemical inputs means that organic food costs more to produce. This makes it less accessible to many people, particularly those on low incomes. The organic market is growing and can start to benefit from economies of scale, reducing some of its costs. In addition, inorganic food is not as cheap as it appears because, the true cost of a food product is not simply the price for which it is sold. Consumers are paying for inorganic food three times over–first over the counter, second via taxation which mainly subsidies inorganic farming and third to remedy the damage that farming and food production has done to the environment and human health (Pretty et al., 2000). A study in the UK calculated that
the total hidden or ‘external’ cost of non-organic farming to the environment and to human health was 2.34 billion per year (based on 1996 data). By contrast organic farming has, only one third of the hidden costs of inorganic agriculture, and would reduce the external costs of agriculture by $2.4 billion, to $180- $210 a hectare (Pretty et al., 2000).

2.3 Organic production in Sudan

In the past the real concept of organic agriculture was not clear in Sudan but the management of agriculture was actually organic as farmers were not using chemical pesticides and fertilizers because of financial or other reasons (Bushara, 2011). With regard to organic agriculture, Sudan’s long history and its many generations show compatible and integrated organic agriculture system managing farms over the decade to reach normal rotations for the production of natural food crops in all areas of traditional agriculture, e.g. cycle crops with the so-called (Gum cultivating cycle). These agriculture characters were benefiting current Sudanese organic proposal idea by European companies for production of sesame and sunflower for Common European market and the Middle East region. FAO (2001) proposal also selected two areas to cover different types of agriculture in Sudan; one is in Gadareef, the second in Sennar state (Awoodh, 2006). An Organic Agriculture Program was initiated in 2001 by Arab Authority for Agriculture Investment and Development (AAAID) with the aims to produce food commodities free of agricultural pollutants (fertilizers and pesticides), through the use of organic fertilizers and bio-resistance factors in pest control. Three areas were selected to cover different types of agriculture in Sudan. The first area was traditional farming areas in the rain - sandy land in the middle, east and western Sudan for Gum arabic; Delta Elgash and Tokar to produce sunflower and watermelon.
The second was mechanized rain-fed agriculture at Sinnar state and the third one was irrigated agriculture - on rivers and valleys for the production of vegetable crops and fruits in River Nile State (Awoodh, 2006). This proposed certified organic land areas were estimated at 200,000 hectare and 650 farms, (Scialabba, 2007). The formal organic sector in the Sudan remains relatively underdeveloped but there are serious steps towards the adoption of organic agriculture which began in 2001 with the inception of the Organic Agriculture Program (OAP), funded by AAAID and implemented by the Ministry of Agriculture and Forestry (MOAF). The Sudanese Society for Organic Agriculture (SSOF) organized a series of workshops between 2004-2006 to create awareness about organic farming among producers, consumers and policy makers. The Common Fund for Commodities (CFC) supports a project to promote the exports of organic bananas from Sudan to the Middle East and Europe. The Sudanese Standards and Meteorology Organization (SSMO) has also been instrumental in pursuing some organic agriculture-related activities (Kamal and Abdelmagid, 2010).

Certification bodies working in Sudan are Ecocert certification body, Centre of Organic Agriculture in Egypt (COAE), and Equal Credit Opportunity Act (ECOA). (Ahmed et al., 2011). Sudanese organic production facing many constraints that are defined as:

1. Lack of access to relevant knowledge and information. Enormous amount of mandatory documentation involved in the process of inspection and certification, which is too cumbersome to maintain for those small farmers, who are illiterate.

2. Difficulties in obtaining reliable information on domestic and international market (suppliers, prices and qualities); more so because the
marketing and information services available in the country all relate to conventional products only.

3. Institutional barriers, such as scarcity of professional institutions capable of assisting the farmers throughout production, post-production and marketing processes.

4. Inadequate availability of different organic inputs, such as organic seeds, bio-fertilizers, biopesticides etc. (Bushsara, 2011).

5. Awoodh (2006) said that poor infrastructure and inadequate marketing system are the main problems facing organic production in Sudan. So it must build its organic food industry on sound bases to avoid setbacks. If Sudanese commodities exported as organic are found to be not complying with the strict standards and specifications, it would cost a lot of time and resources before the Sudan can re-enter the international market on organic products.

With all these constraints marketing is still a bottleneck. The annual worldwide trade of organic products is increasing rapidly from 10-12 billion US$ in year, to 80 billion US$ by 2008 (Awoodh, 2006). Most of Sudanese commodities are free from chemical contamination and could be sold as organic products (Adam, 2008). The world organic market is growing at a rate of 20 percent per year. It will also attract global investors to agricultural production of such crops in Sudan (Babiker, 2003).

2.4 Organic tomato production

Organic tomatoes are always in high demand in both local and whole-sale markets (Diveret et al., 2012). Also according to the results reported by Steven, (1998) the yields produced under the organic systems are very similar to yields produced by the conventional system. In the South Central U.S. (Oklahoma) tomato yields of 650 to 850 boxes per acre are
common, this is equivalent to about 10 to 13 tons per acre. In 1990, the average fresh market tomato yield in South Central U.S. was 25,100 pounds per acre. One organic farmer in New Jersey netted $10,000 an acre. Efficient harvesting, handling, and marketing techniques are extremely important in the production of this highly perishable crop. Harvesting tomatoes is very labor intensive. One source estimates 350 hours for each staked acre (Diver et al., 1999). With the high demand, a choice of organic method was attractive to the organic producer as it sometimes brings a 10-30% premium in the marketplace (Diver et al., 1999).

There is a strong market for organic heirloom tomatoes. Unfortunately, many heirloom tomatoes have little or no disease resistance, making organic production difficult in many areas. A study demonstrated that heirloom tomatoes can be grown organically in western North Carolina, even with late blight present. Yields were very good. Using the average yields obtained across all treatments, 9.2 pounds of fruit per plant, with 6290 plants per acre, and prices of $2.00 per pound, estimated gross returns would be $115,736 per acre (Davis and Gardner, 2007).

Large-scale monoculture production is a feature of conventional processing tomato operations. Processing tomatoes are mechanically harvested and transported in bulk carriers to processors. Organic production on the same scale is unlikely to be successful. However, careful field layout involving intercropping with other species or staggering plantings could increase the scale of operations and extend the harvest period. Contracts for processing tomatoes are difficult to obtain unless you are an established producer. Contracts are issued before the season begins. The economics of organic processing tomato production will largely depend on the market you are targeting. On-farm value-added products will return more than unprocessed tomatoes sold to a processor. However, the labour and
infrastructure requirements for on-farm value-adding will be significantly greater. So, returns will largely depend on how much effort, time and initial resources you are prepared to outlay. Returns will also depend on costs of inputs (labour, fertilizer), yield, quality, the type of market you target (fresh or processed) and supply and demand for your product (Neeson, 2004).

Greenhouse technology and horticultural practices differ little between conventional and organic greenhouse production. The main variations are concerned with pest control and fertility. Organic greenhouse vegetable production has potential as a niche market for out-of-season produce and as a sustainable method of production. Tomatoes are the leading greenhouse vegetable crop. A greenhouse has high infrastructure cost, prior to sinking lots of money into a greenhouse venture, growers should examine produce prices in their region and estimate their cost of production. Income in the USA from conventional greenhouse tomatoes range from $3,100 to $18,500 per greenhouse unit. These estimates are for good yields and favorable market conditions. Low yields, or a dip in the market, can lead to negative returns to the grower. Historically, the break-even price for most greenhouse tomatoes has been around 5 cents per pound, with selling prices ranging from 90 cents to $1.60 per pound. Greenhouse tomatoes yields determine potential gross sales. Typical yields of organic greenhouse tomatoes are 9 to 13 kgs per plant (Greer and Diver, 2000).

2.4.1 Soil fertility

The most critical factor of organic tomato production was maintaining and building a microbially-active soil enriched with organic matter and a balanced mineral diet (Diver et al., 2012) by cover crops, organic mulching, compost with aged manures. These practices not only
supply plant nutrients but also increase tolerance to insects and diseases, help control weeds, retain soil moisture and ensure produce quality (Diver et al. 2012). Research using cover crops and various rates of nitrogen over a four year period showed that cover crops produced higher yields and better quality tomatoes than applied nitrogen (Batal et al and Hall, 1995).

2.4.2 Pests and diseases

Cultural practice of organic tomato production play vital role in the management of pests and diseases (Diver et al., 2012). The pests' management of organic tomato system permits a wide range of biorational pesticides to keep pests below damaging levels (Diver et al., 2012). Crop rotations and trap crops are effective in controlling pests, either by attractive plants e.g. sweet corn for tomato fruit worm (NABARD, 2007); or by natural repellants e.g. garlic, onions, zinnia, marigolds, and nasturtium, to repel insects such as aphids or whiteflies (Diver et al., 2012). Drinkwater et al. (1995) reported that no significant differences were found between organic and conventional farms in overall insect damage. Organic tomato disease control programs are based on a combination of organic soil management practices, Integrate Pest Management (IPM) practices, natural remedies, and limited fungicide use (Diver et al., 2012).

2.4.3 Managing Weeds

There is a wide variety of approaches to control weeds without use of synthetic chemicals. Crop rotations in combination with cover crops have proven to be the foundation of organic farming. Complementary to crop rotations is the use of mulching for adequate weed control (Diver et al., 2012). According to USDA researchers, the use of hairy vetch as a no-till mulch crop for tomatoes, obtained yields averaging more than
45 tons/acre. This was trailed by yields of 35 tons/acre using plastic mulch, and 34 tons/acre using paper mulch. Control plots with no mulch averaged 19 tons/acre (Abdul-Baki et al., 1995).

2.5 Tomato production in Sudan

Tomato in Sudan has been produced in the open field primarily in winter and secondarily in summer production. Annual tomato production is about 300 000 tons which is far below requirement of the local market. The import of tomato estimated at $ 5 million (FAO, 2001). The lagging of supply behind demand of tomato production lead to the start of greenhouse industry to improve tomato productivity especially for off season. In Khartoum State the total number of greenhouses is 764 (73 multispan and 472 single greenhouse). The total area estimated is about 240193 m². The greenhouse which produced off season tomato estimate about 19 multispan and 255 single greenhouse on 61724 m² representing about 25.7 % of total area of green houses. The production of a single greenhouse is 4.5 tons, total production cost is $1,310, while income estimate by $ 1,434 (Ministry of Agriculture Khartoum State, 2011).
CHAPTER THREE
MATERIALS AND METHODS

3.1 Experimentation

Organic production generally means anti-synthetic production inputs. In this experiment organic fertilizer was used together with organic insecticide and/or water extracts of ‘neem’ (*Azadirachta indica*) seed kernels (N) and argel (*Solenstemma argrl*) leaves (A). Tomato was used as a model for organic production practices.

3.2 Site

The experiment was planted on November 22, 2011 in the orchard of Horticulture Department, of the Faculty of Agriculture, University of Khartoum, Shambat (latitude 15° 36’ N, longitude 32° 31’ E, at elevation of 376 meters above the sea level) on clay loamy soil and semi-arid tropical climate.

3.3 Production of seedlings

The tomato seeds of the variety Peto-86 were sown on October 24, 2011 in the green-house in trays filled with peatmoss. They were irrigated every three days. Seedlings were sprayed with vertamic insecticide twice. The green house was almost insect-proof.

3.4 Land preparation

The experiment was conducted in an area of 300 m² which was ploughed and chicken manure was distributed and disc harrowed and ridged at East-West direction at 0.8m wide. Plots comprised 3 ridges 3m long.
The chicken manure was used as organic fertilizer and was applied for all plots at 1kg/m² three weeks before planting and was irrigated every week to allow the decomposition of the fresh organic manure and to release the heat generated during fermentation before transplanting the tomato seedlings. Plastic mulching for weeds control were used in all treatments.

3.5 Preparation of extract and treatments

- Vertamic 018EC insecticide was used at the rate of 5ml/L.
- ‘Neem’ seed kernels were crushed and soaked in water for 24 hour at the rate of 50g/L. The extract used to control a wide base of insects (Mohammed, 2002).
- Argel leaves were crushed and soaked in water for 24 hour at rate 10 g/L. The extract used to control the infestation of aphids (Mohammed, 2002).

3.6 Experimental design and treatments

The layout of the experiment was randomized complete block design with four replications. Three organic pesticides treatments were used. Vertamic 018EC insecticide, Neem seed kernels’ water extract and Argel leaves’ water extract. Control treatment received no spraying. Four times spraying started four weeks after transplanting at two weeks intervals.

3.7 Data collection

3.7.1 Vegetative growth parameters

After one month from transplanting, a sample of five plants per treatment was taken every two weeks for five times and the following parameters were recorded:-

(i) Number of leaves/plant.
(ii) Number of trusses/plant.
(iii) Number of flower buds/truss.

3.7.2 Yield parameters

From 6 weeks after transplanting (WAT) Weekly harvest of five plants was classified into marketable and unmarketable yield. Total number of harvests were eight.

At the end of the experiment five plants per treatment were taken and their average fresh and dry weights were recorded.

3.8. Statistical analysis

Collected data were statistically analyzed using Statistical Analysis System (SAS, 1999).
Plate 1: Plastic mulching 3 week after transplanting (WAT)
Plate 2: Field after covering
Plate 3: Field of tomato 5 week after transplanting (WAT)
CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Effect of spraying with vertamic, neem and argel on the vegetative and reproductive growth parameters of open field tomato production during 6-14 WAT

4.1.1 Number of branches /plant

Table 1 shows that there was no significant difference in the number of branches/plant among the treatments. The highest number of branches was obtained from the control treatment (7.46) that might be due to the fact that damage inflicted by insect pest induced the plants to produce more branches as compensation. The argel treatment gave the lowest number (6.3) of branches/plant. This result disagree with Abdelwahab (2002) who reported that in an infested field experiment of Brassica nigra, aphids disappeared as a result of spraying with argel and vegetative growth was restored and the plants flowered within 10-15 days after treatment by argel. Ahmed (2007) showed that argel treatments significantly increased number of bunches /palm tree compared with untreated palm trees when he added dry leaves of argel directly as fertilizer to the soil.

4.1.2 Number of trusses/plant:

There was no significant difference in the number of trusses/plant among treatments (Table 1). The highest number of trusses was obtained by Vertamic treatment (10.36), followed by Neem (10.06) then argel (9.71), and the control (9.5). Argel gave a slightly higher number of trusses/plant than the control, which agreed with Ahmed (2007) who reported that argel
Table 1. Effect of spraying with vertamic, neem and argel on the average number of branches/plant, number of trusses/plant and total number of flower buds/plant during 6-14 WAT

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Branches per plant</th>
<th>Trusses per plant</th>
<th>Total flower buds per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertamic</td>
<td>7.1a</td>
<td>10.4a</td>
<td>47.4a</td>
</tr>
<tr>
<td>Neem</td>
<td>7.2a</td>
<td>10.1a</td>
<td>50.7a</td>
</tr>
<tr>
<td>Argel</td>
<td>6.3a</td>
<td>9.7a</td>
<td>45.7a</td>
</tr>
<tr>
<td>Control</td>
<td>7.5a</td>
<td>9.5a</td>
<td>46.3a</td>
</tr>
</tbody>
</table>

Means with the same letter were not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.
treatment significantly increased the number of spikes/bunch on date palms for two seasons of experiment. That difference might be due to the concentration of the sprayed extract as compared to use of leaves as organic fertilizer in the soil.

4.1.3 Total number of flower buds/ plant

Number of total flower buds per plant was not significantly different among the treatments (Table 1). The highest number of total flower buds was obtained from Neem treatment (50.7) which could be explained by the fact that Neem might have hormone-like effect which enhanced flower bud production. This agrees with Abolusoro and Oyedummade (2002) who reported superior growth and yield of tomato plants which were treated by neem against *Meloidogyne incognita* root-knot nematode. That is, reduced nematode population in the treated soil was the cause. On the other hand, the lowest number of flower buds resulted from argel (45.7) which is not in line with Ahmed (2007) findings on spike/bunch of date palm.

4.2. Effect of spraying with vertamic, neem and argel on marketable and unmarketable yield of tomato

Figures 1 and 2 show marketable and unmarketable yield /plant (g) during the period 10-17 WAT. Use of vertamic gave the highest marketable and unmarketable yields. This might be because vertamic resulted in the highest number of trusses /plant and second best total number of flower buds/plant (Table 1). Both of these effects were reflected in the weekly harvests.

Neem extract treatment gave inconsistent results for marketable and unmarketable yields during the period 10-17 WAT (Figures 1 and 2). However, it gave low unmarketable yield (6.3 t/ha) that might be due to its
effectiveness as an insecticide. Marketable yield was significantly different (Table 2).

This result agreed with Alhaj (2006) who reported that the different dose of Nimbecidine (neem products) significantly increased onion yield compared with untreated control.

Use of argel gave highest marketable yield (120g) 15 WAT and the highest unmarketable yield (98g) 16 WAT and (130g) 17 WAT (Figures 1, 2). Abdelwahab (2002) reported that argel application to aphid-infested Brassica nigra plants induced growth and flowering. Moreover AbdAlla (2006) reported that argel application increased yield of date palm by insecticidal effect.

 Marketable yield was significantly different among treatments (Table 2). Vertamic gave significantly higher value (19.4 t/ha) than the other treatments; but there were no significant differences among the other organic pesticides and control (Table 2). Unmarketable yield showed no significant differences among treatments. The highest unmarketable yield was obtained from Vertamic (9.4 t/ha) treatment and the lowest was obtained from neem (6.3 t/ha) treatment. Davis and Gardner, (2007) found no significant difference in tomato yield among different production systems of conventional (4.1 kg/plant), Organic (4.1 kg/plant), Brandt (organic) (4 kg/plant) and control (3.9 kg/plant). This agrees with the results obtained by Bettiol et al. (2004) who found that the marketable and unmarketable yields were not significantly different in organic system. But also found significant difference in inorganic system. Total yield showed significant differences among treatments, where the highest total yield was given by vertamic (28.6 t/ha) followed by neem (17.5 t/ha) and the control (17.5 t/ha) and argel (16.9 t/ha).
The percent of marketable total yield of vertamic recorded higher value (67.4%), followed by neem (64.3%), control (64.3%) and argel (59.2%) (Table 2). However, argel gave the highest (40.8%) percent of unmarketable total yield followed by control (40.8%), neem (35.7%) and vertamic (32.6%).

The highest value of percent change over the control of marketable yield was attained by vertamic (82.4%) followed by neem (58.9%) and argel (-5.9%). Also vertamic gave highest value (36.4%) of percent change over control of unmarketable yield followed by argel (0.0%) and neem (-9.1%). The treatments vertamic, neem and argel inhibited (64.3%) (0.0%) (-3.8%) respectively, on percent change over control of total yield (Table 2). Highest percent change over control of marketable, unmarketable and total yield was brought about vertamic.
Figure 1. Effect of spraying with vertamic, neem and argel on marketable tomato yield/plant (g) during the period of 10-17 WAT.
Figure 2. Effect of spraying with vertamic, neem and argel on unmarketable yield/plant (g) of open field tomato during the period of 10-17 WAT.
Table 2. Effect of spraying with vertamic, neem and argel on the marketable (t/ha), unmarketable (t/ha) and total yield (t/ha) 16 WAT.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Marketable</th>
<th>% Marketable</th>
<th>%Change over control</th>
<th>Unmarketable</th>
<th>% Unmarketable</th>
<th>%Change over control</th>
<th>Total yield</th>
<th>%Change over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertamic</td>
<td>19.4 a</td>
<td>67.4</td>
<td>82.4</td>
<td>9.4 a</td>
<td>32.6</td>
<td>36.4</td>
<td>28.8 a</td>
<td>64.3</td>
</tr>
<tr>
<td>Neem</td>
<td>11.3 b</td>
<td>64.3</td>
<td>58.9</td>
<td>6.3 a</td>
<td>35.7</td>
<td>-9.1</td>
<td>17.6 b</td>
<td>0.0</td>
</tr>
<tr>
<td>Argel</td>
<td>10.0 b</td>
<td>59.2</td>
<td>-5.9</td>
<td>6.9 a</td>
<td>40.8</td>
<td>0.0</td>
<td>16.9 b</td>
<td>-3.8</td>
</tr>
<tr>
<td>Control</td>
<td>10.6 b</td>
<td>60.7</td>
<td>0.0</td>
<td>6.9 a</td>
<td>39.3</td>
<td>0.0</td>
<td>17.5 b</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Means with the same letter were not significantly different at P ≤ 0.05 according to Duncan's Multiple Range Test.
4.3 Effect of spraying with vertamic, neem and argel on fresh and dry weight of plants 17 WAT.

4.3.1 Fresh weight

There was significant difference in fresh weight of plants among treatments (Table 3). The highest was by vertamic treatment (1.8 kg) and the lowest was from the control (1.3 kg). This could be attributed to the fact that control plants were negatively affected by insects and diseases from the beginning of the season where symptoms appeared as stunted and dried parts of plants. This result is not in line with the findings of Mahbuba et al., (2008) who reported that there were no significant differences among the different pesticides after studying the effect of (admire (0.1%), cymbush (0.1%), nimbicidin (extraction of neem) (0.1%) and organic oil namely soybean oil (1%)) on the incidence of tomato yellow leaf curl virus (TYLCV) on healthy plants.

4.3.2 Dry weight

There was no significant difference in dry weight of tomato plants among insecticides at the end of the growing season. The lowest dry weight was obtained from argel treatment (0.18 kg), and the highest dry weight obtained from control (0.55 kg). This disagrees with Mahbuba et al., (2008) who found that the dry weights per plant among different pesticides (Admire (0.1%), Cymbush (0.1%), Nimbicidin (0.1%) and Organic oil namely soybean oil (1%)) were significantly different.
Table 3. Effect of spraying with vertamic, neem and argel on plants fresh and dry weight (kg) at 17 WAT.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fresh weight of plants</th>
<th>Dry weight of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertamic</td>
<td>1.8a</td>
<td>0.18a</td>
</tr>
<tr>
<td>Neem</td>
<td>1.5 ab</td>
<td>0.18a</td>
</tr>
<tr>
<td>Argel</td>
<td>1.6ab</td>
<td>0.18a</td>
</tr>
<tr>
<td>Control</td>
<td>1.3b</td>
<td>0.55 a</td>
</tr>
</tbody>
</table>

Means with the same latters were not significantly different at P ≤ 0.05 according to Duncan's Multiple Range Test.
4.4 Conclusion

Vertamic was the best of the three tested organic pesticides. Compared to the reported conventional tomato yield of (13.37 t/ha) Ministry of Agriculture and Forestry data (2006-2007-2008), use of organic pesticide vertamic gave higher yield (19.4 t/ha).

Further research needs to be carried out to confirm the above results.
Plate 4: Stunted control plants
REFERENCES


NABARD, (2007). Model Bankable Scheme for Organic Cultivation of Tomato in Jharkhand. Site designed & developed Web Werks India Pvt Ltd.


