Vermiculture for Sustainable Horticulture: Agronomic Impact Studies of Earthworms, Cow Dung Compost and Vermicompost Vis-à-vis Chemical Fertilizers on Growth and Yield of Lady's Finger (*Abelmoschus esculentus*)

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Abstract

Pot experiment was conducted to assess the performance of live earthworm and vermicompost on growth and yield of lady's finger (*Abelmoschus esculentus*). Among the various treatments, live earthworm + cattle dung (as feed) (P1), cow dung compost (P2), vermicompost (P3), chemical fertilizer (P4) and control (P5) were organized. The results indicated that all yield parameters were found numerically superior and significantly higher (bud initiation- 30 days, flower formation- 36 days, number of buds and flowers - 50 and 47, number of fruits- 225, maximum weight of fruit- 70g, maximum length of fruit- 9.4'') in the pots with live earthworm + cattle dung (as feed) in comparison to others. Vermicompost used alone responded better than chemical fertilizer in which maximum average fruit weight and length were observed 40 g and 13.72 cm. Growth attributes indicated that lady's finger plants with live earthworm treatment showed early onset of germination than others with 100 percent survival rate of seedlings. The overall performance of plant growth was witnessed significantly better at 5 percent level in plants grown with live earthworm

and vermicompost in soil. Another significant observation was that very mild disease appeared in the plants where earthworms were resident in the soil. After repeated use of live earthworm in the same soil many of the plant growth parameters were found numerically superior and significantly improved at 5 percent level over the period of time which proved that earthworms are really the 'friend of farmers'. It can extensively improve the soil fertility if present consistently in farm soil.

Keywords

Earthworms (*Eisenia fetida, and Eudrilus eugeniae, Perionyx excavatus*), vermicompost, Cattle dung, plant growth

1). Introduction

The 'Green Revolution' in the 1960s and 70s ushered by the heavy use of agro-chemicals, increased food productivity but also created several socio-economic and environmental problems like decreased nutritional quality of food produced, decreased soil fertility, higher demand for water for irrigation, soil and water pollution and pesticide poisonings (Sinha 1998 and 2004, Sinha et al. 2009). The pesticide remains in vegetables can cause neurological and blood disorders, lung ailments and affect the reproductive system of women (Mandal, 2009). Sharma (2009) reported that indiscriminate use of chemical fertilizers in the wake of Green Revolution in Punjab has pushed the State to the brink of health hazards like 'blue baby syndrome' and cancer.

To preserve the global agro-ecosystems and protect human health from the harmful agro-chemicals 'Ecological Agriculture and Organic Farming' has to be promoted (Gomiero, 2008). Ecological agriculture is relatively more sustainable, and it could be an economically and environmentally viable alternative to the destructive chemical agriculture (Rasul, 2003, Sinha 2004*).* The effective utilization of 'biological fertilizers' for vegetable crops will not only provide economic benefits to the farmers but also improve and maintain the soil fertility and sustainability in natural soil eco-system (Kannaiyan, 2002). Thus the rationale of the study is to establish a sustainable

method of horticulture with the use of vermicompost and live earthworms in the pot replacing chemical fertilizers.The live earthworms provide dual benefits by making good use of kitchen waste along with the provision of healthy organic vegetables.

2). Objectives of the Study

This study was undertaken to develop a sustainable method of 'backyard vermicomposting and vegetable farming' and establish the importance of organically grown vegetables. The objective of this work was to compare the growth impacts of live earthworms, earthworm's vermicompost, cattle manures and chemical fertilizer on growth and yield of lady's finger *(Abelmoschus esculentus)* along with this disease incidence was also observed.

3). Methods and Material

Lady's Finger (*A. esculentus*) plants were grown in pots of 30.48 cm height and 25.4 cm diameter filled with about 9.5 kg near neutral soil from kitchen garden. Following treatments were organized.

(1). Mixed species of live earthworms (*Eisenia fetida, and Eudrilus eugeniae Perionyx excavatus* + one week old cattle dung as feed material in soil (P1),

(2). Only cattle dung in soil (P2)

(3). Vermicompost in soil (P3)

(4). Chemical fertilizer in soil (P4) and

(5). Control (P5).

Altogether 25 pots were prepared with sieved soil and then thoroughly mixed with various inputs (Table-1). Five replicates were grown for each treatment. In lady's finger crops 130 kg nitrogen, 80 kg phosphorus and 130 kg potassium (per hectare) is ideally required for good growth.

Insert Table 1 here

Considering the objective of kitchen waste degradation along with organic farming the epigeic earthworms *Eisenia fetida, and Eudrilus eugeniae* were selected as they are voracious eaters In the pots with live earthworm, additional feed material was added in

the form of kitchen waste weekly during the experiment. Chemical fertilizer consisting urea, single super phosphate and muriate of potash were added. Urea was added in three divided doses as per package and practices given by Department of Horticulture, Government of Rajasthan. The first dose was applied after a week of sowing. Lady's finger seeds were presoaked in water overnight for 12 hours with bavistin as a preventive measure to avoid the incidence of any plant disease. Five seeds in each pot were sown. Out of five seedlings only one healthy plant was allowed to grow up to maturity. Initially, 2 litres of water was added in soil to make it wet. Afterwards 500 ml of water was added in summer everyday. During winters same amount of water was added every alternate day and during peak winters 500 ml water was added every third day.

The soil was sun dried for 15 days and reused for next experiment .. The experiment was repeated 3 times in spring, summer and spring seasons that were March, June and March. During peak seasons pots soil was covered with jute / coconut husk when temperature was low to protect earthworms. In high summers, pots were covered with wet jute / coconut husk to prevent evapourational losses of water from the soil. All the pots were arranged in such a manner that plants received uniform sunlight.

Completely Randomized Design was used to evaluate the growth and yield of vegetable plants. Growth parameters studied were seed germination, seedling formation, rate of survival of seedling, vegetative growth were studied. Yield parameters studied were flower bud initiation, flower formation, number of buds and flowers and quantity and quality of fruit produced. Incidences of disease in lady's finger plants were also studied for which plant pathologist was considered to examine the disease and suggest for treatments. His suggestions were recorded and used during the experiment.

4). Results and Discussion

The experimental results revealed that the yield and growth parameters were influenced positively by the presence of live earthworms in soil.

4.1 Effect on Seed Germination and Survival Rate of Seedlings

Seed germination was found numerically higher in pots with live earthworms. No apparently difference was observed in seed germination in cow dung and vermicompost applied pots. There was no influence observed by chemical fertilizer over seed germination (Table-2). Owa (2008) also indicated that in the presence of live earthworm in soil, seed germination improves as a result of better soil aeration (and hence improved oxygenation) by burrowing action of earthworms.

Insert Table 2 here

Potted plants with earthworm ranked first in survival rate of seedlings. The results for survival rate were recorded till day 16. In pots with live earthworms 100 percent survival of plants were recorded.

4.2 Effect on Vegetative Growth of Lady's Finger Plants

Vegetative growths in all treatments were recorded till 90^{th} day. The tallest lady's finger plant was observed in pot soil with live earthworms. It was 100.08 cm in height with good foliage and branching. It was followed by those on vermicompost. Cow dung and chemical fertilizer had shown similar results influencing the parameter plant height. (Table 3, Fig. 1). Gutierrez et al. (2007) reported that addition of vermicompost increased plant heights and yield of tomato ***(Lycopersicum esculentum)*** significantly which confirms the results of the present study.

Insert Table 3 here

Insert Figure 1 here

4.3 Effects on Budding and Flowering Times of Plants

Time taken for budding was less in pots with live earthworm which took 38 days. Similarly flower formation occurred in 48 days in live earthworm resident pots. As compared to vermicompost chemical fertilizer had shown better results in flower formation and number of flowers produced. But gradually the condition reversed with successive use of vermicompost. Highest numbers of buds were observed in plants treated with live earthworm .Vermicompost produced average 31 buds / pot initially.

The similar results were observed by Sinha and Valani (2009) that tomato plants on exclusive vermicompost and vermicompost with worms' maintained very good growth from the very beginning. Number of flowers and fruits per plant were also significantly high as compared to those on agrochemicals and conventional compost. Presence of live earthworms in soil made a significant difference on the flowering and fruiting of tomatoes.

Insert Figure 2 here

Insert Figure 3 here

A different pattern was observed in average number of buds / pot and the number of buds converted in to flowers / pot. In vermicompost during all the 3 experiments 90-91 percent buds converted into flowers whereas in live earthworm resident pots initially 82 percent buds converted into flowers which increased up to 94 percent flowers in the last experiment (Table-4).

The weight and length of fruit and number of fruits / plant is one of the most important yield contributing traits in lady's finger and was found maximum when treated with live earthworms followed by vermicompost and cow dung compost. Average number of fruits/ plant was highest in live earthworm followed by vermicompost and cow dung compost. Azarmi et al. studied on tomato (*Lycopersicum esculentum* var. Super Beta) and the results of their study supported the findings of our study that vermicompost has positive effect on growth, yield and elemental contents of plant as compared to control.

Chand et al. (2008) experimented on tomato plants to find out the effect of natural fertilizers on their yield and quality .They found that significantly highest yield was recorded in the treatment receiving enriched vermicompost along with 3 sprays of liquid manure. Similar trend was observed in development of fruit length and fruit girth. They also confirmed that earthworms significantly improve plant growth. The results of Meena et al. (2007) show the growth impacts of organic manure on garden pea (*Pisum sativum*) as compared with chemical fertilizers. Organic nitrogen (N) nutrition produced higher green pod plants, higher green grain weight per plant,

higher percentage of protein content and carbohydrates and higher green pod yield (24.8-91 percent) as compared to chemical nitrogen (N).

Average number of flowers converting into average number of fruits / plant was mostly (90.9 percent) in live earthworms. Number of fruits/plant was found significantly higher in all treatments over control at 5 percent level. In the 1st experiment there was no significant difference found between P3 and P4 but with the repeated use of vermicompost, soil quality improved and resulted into significant difference in 3rd experiment between P3 and P4 (Table-5). Live earthworm significantly influenced number of fruits/plant, while P5 had shown the least number of fruits/plant and P4 was found intermediate between P3 and P5. By the end of 3rd experiment 95.74percent flowers were converted into fruit. This was followed by cow dung.

Average weight of fruit / plant was higher in live earthworms (48g) in first experiment (Table-4). Based on the Critical Difference (CD) values the weights of fruit were found to be significantly higher in all treatments over control. Live earthworm was observed superior over all treatment in all the three experiments. But no significant different was observed in P3 and P4 in experiment 1, 2 and 3 at 5 percent level. Whereas the minimum fruit weight was found in P5 for all the three experiments. (Table-5). Similarly average length of lady's finger fruit was measured 18.29 cm, 14.73 cm and 16.26 cm where plants were treated with live earthworm. In chemical fertilizer grown plants the conversion of buds to flowers and flowers to fruits could not go beyond 90.6 percent and 90 percent respectively in the first experiment which reduced after further use of fertilizer. Fruit length was found maximum in the first experiment (13.72 cm) with chemical fertilizers. The findings of Worthington (2004) confirm that there is genuine difference in the nutrient content of organic and conventional crops.

Insert Table 4 here

4.4 Incidence of Diseases on Plants

In all experimental plants symptoms of 'Yellow Vein Mosaic', 'Color Rot' and 'Powdery Mildew' diseases were observed. But severity of diseases varied and responses to chemical control were also different in different treatment pots. In plants with live earthworms (P1) and vermicompost (P3), the disease appeared very mild and was eradicated in very 1st treatment made with Kerathene and Nuvacron chemicals within 10-12 days. Whereas, in plants in control pots and on cow dung and chemical fertilizers diseases appeared more pronounced, and they had to be treated more number of times to control. It took almost 16 days to completely eradicate them. Similar results were reported by Elmer (2009). Soil infested with soil borne pathogens and augmented with earthworm (*Lumbricus terrestris*) could reduce disease of susceptible cultivars of asparagus (*Asparagus officinalis*), eggplant (*Solanum melongena*), and tomato (*Solanum lycopersicum*) very soon. The results of Nagavallemma et al. (2004) also confirms the findings of the present study that earthworms create good quality soil and additives which enhances water holding capacity along with development of resistance in plants to pest diseases.

Insert Figure 4 here

5). Conclusions and Remarks

The study has clearly established that the presence of earthworms in soil makes significant difference in crop growth and development especially in flowering and fruiting. Repeated consistent use of earthworm in soil literally showed surprising results with improved growth and yield attributes. This is obviously due to more 'growth and flowering hormones' (auxins and gibberlins) available in soil and around the plant roots secreted by live earthworms (Sinha et al., 2009). It is reported by Scheu (2002) that studies on earthworm-plant interactions may contribute significantly to a more comprehensive understanding of terrestrial ecosystems and to the development of more environmentally friendly agricultural practices.

All growth promoting substances of the earthworms are excreted and stored in its excreta (vermicast) and hence use of vermicompost in soil also gives the same results. But the presence of live earthworms in vermicompost multiplies the impact. Sinha et.

al., (2009 and 2010) also observed that the 'worm effect' on plant growth is more pronounced in horticultural crops (fruits and vegetables plants) whose fruits are of economic value, than on the cereal crops whose seeds are of economic importance.

With addition of live earthworms in pot soil some feed materials have to be added for the worms to feed upon and act. Sinha et al., (2009) observed in case of corn crops that when the worms are added alone (without any feed material) in the pot soil, the growth impact is not significant as when applied together with feed materials. The worms feed upon the feed materials and excrete vermicast, and with it, all growth promoting substances e.g. growth hormones, humic acids, essential nutrients and beneficial microbes. Together the earthworms and their vermicast enhance plant growth considerably. However, in all vermicompost application in pot soil, worms necessarily grow out from their cocoons and a rich population of earthworms soon abounds the soil.

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Table-1 Quantities of various inputs used in pot soil

S.No.	Symbol	Inputs used in soil	Quantity
1.	P1	Live Earthworm cattle dung	50 (number) 250 g
2.	P2	Only cattle dung	250 g
3.	P3	Vermicompost	300 g
4.	P4	Chemical fertilizer (Urea, S.S.P., M.O.P)	1.40, 2.50, 1.04 g
5.	P5	Control	No Input Given

(Quantities calculated on the basis of per hectare requirement of N, P and K given by Package and Practices, Deptt. of Horticulture, Government of Rajasthan.)

Table-2 Impact of treatments on germination and survival rate till 16th day

Treatments	Experiment Number	Germination in % (Days)						Survival Rate (%)
		3	4	5	6	7	8	On 16th Day

P1	**1**	75	80	100				100
	2	70	80	100				90
	3	80	90	100				100
P2	**1**		60	60	70			70
	2		50	60	80			60
	3		60	70	80			80
P3	**1**			40	60	70		80
	2			30	70	80		70
	3			50	70	80		80
P4	**1**			50	60	70	75	80
	2			20	50	60	65	65
	3			50	60	70	70	70
P5	**1**				30	35	40	40
	2				40	45	50	45
	3				35	40	45	45

a. Experiment-1 indicates experiment done in spring.

b. Experiment-2 indicates experiment done in summer.

c. Experiment-3 indicates experiment done in spring.

(The values given are mean values)

Table-3 Impact of live soil earthworms, vermicompost and chemical fertilizers on vegetative growth of Lady's Finger plants *(A. esculentus)* **heights (In Cm)**

Treatment	**Experiment Number**	**3rd Day**	**5th Day**	**7th Day**	**9th Day**	**11th Day**	**13th Day**	**15th Day**	**30th Day**	**45th Day**	**60th Day**	**90th Day**
P1	**1**	2.03	3.05	3.56	4.83	7.11	7.62	10.67	20.32	44.45	65.02	92.71
	2	1.52	2.03	2.54	4.06	5.59	7.11	8.64	16.51	28.45	43.94	59.44
	3	2.29	3.56	4.06	5.08	7.62	9.65	11.43	22.86	47.24	66.80	100.08
P2	**1**	-	2.29	2.79	5.33	5.33	7.62	8.89	12.70	25.40	40.64	61.47
	2	-	1.27	2.03	2.79	4.57	5.84	7.37	13.72	25.40	40.89	56.39
	3	-	1.78	2.79	5.08	7.37	8.64	9.65	15.24	29.97	55.88	76.20
P3	**1**	-	2.03	2.79	5.08	6.35	7.62	8.13	14.22	28.45	45.97	67.56
	2	-	1.02	1.78	2.54	4.06	5.59	6.86	12.70	24.13	38.61	53.59
	3	-	2.03	3.05	5.08	6.35	7.62	8.13	14.22	28.45	46.74	75.18
P4	**1**	-	1.78	2.54	4.57	3.05	6.35	8.89	12.19	22.61	43.69	73.91
	2	-	-	1.27	2.03	3.05	4.57	5.84	10.16	19.81	35.81	50.80
	3	-	1.27	2.29	3.30	4.06	5.33	7.87	11.43	21.84	41.15	69.85

P5	**1**	-	-	-	2.54	3.56	5.08	6.60	8.38	19.81	37.08	65.02
	2	-	-	-	1.52	2.29	4.06	5.08	9.14	16.76	32.00	45.72
	3	-	-	-	2.29	3.30	4.32	5.59	7.62	18.03	33.53	59.44

(The values given are mean values)

Table-4 Influence of various treatments and their consistent application on yield component in lady's finger plant

Treatments	**Experiment Number**	**Number of buds/pot**	**Number of flowers /pot**	**Total number of fruits**	**Conversion (%)**	
					Bud to flower	**Flower to fruit**
P1	**1**	38	33	150	86.84	90.9
	2	29	24	100	82.75	83.3
	3	50	47	225	94	95.74
P2	**1**	35	31	140	88.57	90.32
	2	24	19	80	79.6	84.21
	3	46	43	200	93.47	93.02
P3	**1**	31	28	125	90.32	89.28
	2	22	20	80	90.9	80
	3	44	40	180	90.9	90
P4	**1**	32	29	125	90.6	90
	2	19	16	70	84.21	87.5
	3	30	27	120	90	88.88
P5	**1**	18	14	60	77.7	85.71
	2	13	11	45	84.61	81.81
	3	17	15	110	88.23	146

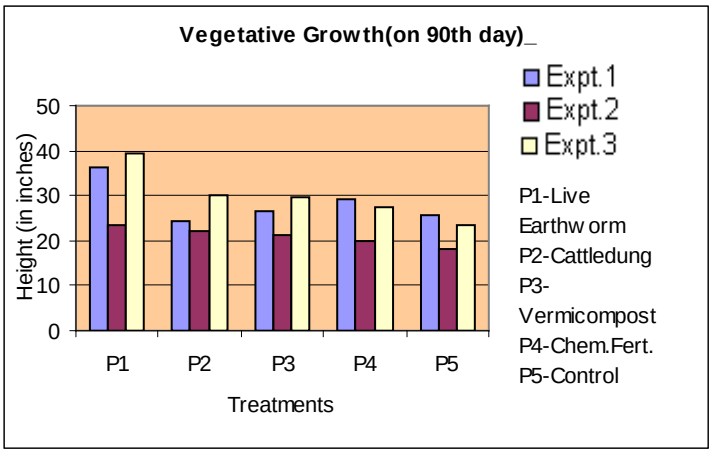
(The values given are mean values)

Table-5 Effect of live earthworm, cowdung compost, vermicompost and chemical fertilizer on number of fruits/plant and weight of fruit in lady's finger

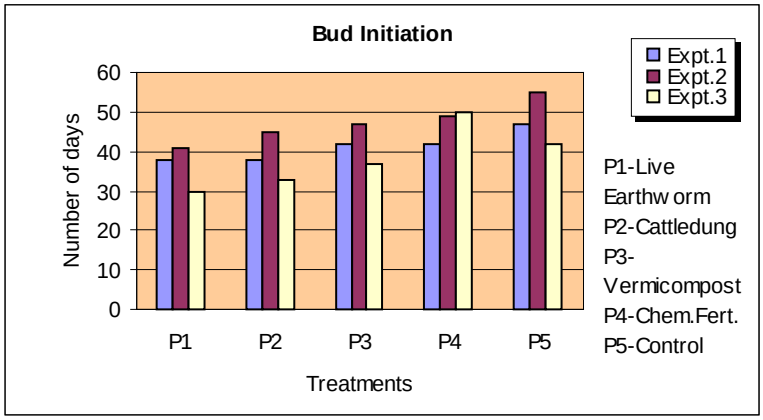
Treatment	Number of Fruits			Weight of Fruits		
	Experiment Number-1	Experiment Number-2	Experiment Number-3	Experiment Number-1	Experiment Number-2	Experiment Number-3
P1	30	20	45	48	40	45
P2	28	16	40	45	38	42
P3	25	16	36	42	35	40
P4	25	14	24	40	30	38
P5	12	9	22	38	28	32
S.Em±	1.26	1.21	1.24	1.54	0.53	1.2
C.D. at5%	3.09	2.97	3.05	3.76	2.93	2.93

SEm-Standard error mean

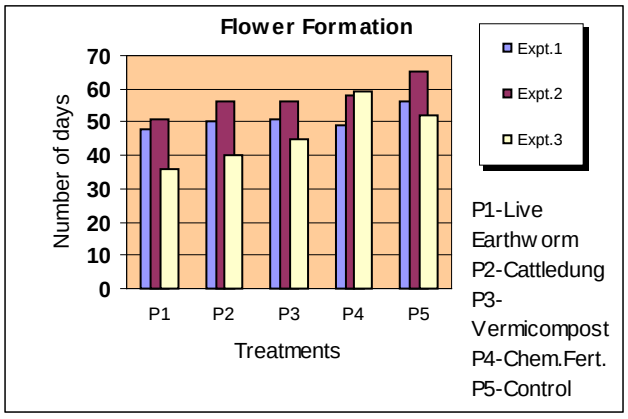
C.D.-Critical difference

2. 

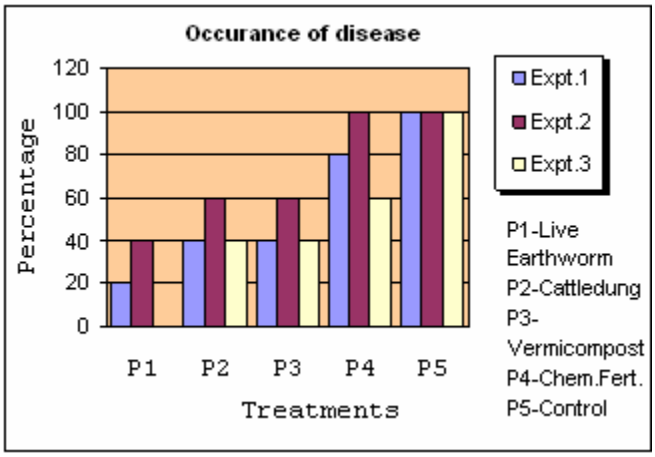
3.Fig. 1 Graph showing vegetative growth of lady's finger plants promoted by earthworms with cattle dung, only cattle dung, vermicompost and by chemical fertilizers

4. 

5.Fig. 2 Graph showing bud initiation of lady's finger plants promoted by earthworms with cattle dung, only cattle dung, vermicompost and by chemical fertilizers

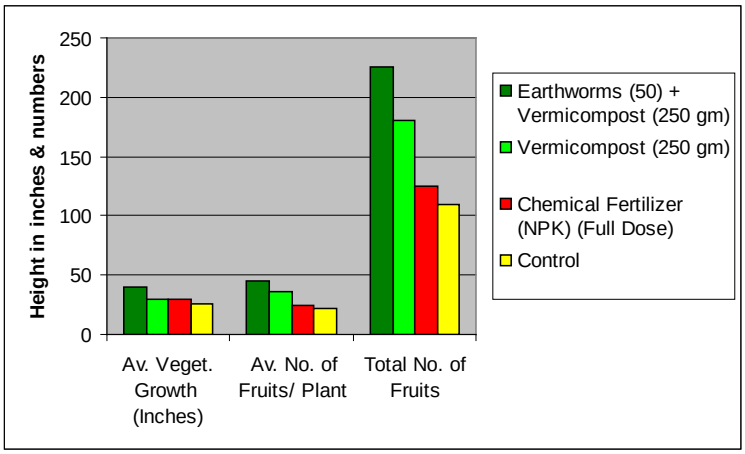
6. 

7. Fig. 3 Graph showing flower formation of lady's finger plants promoted by earthworms with cattle dung, only cattle dung, vermicompost and by chemical fertilizers

8. 

9. Fig. 4 Graph showing percentage occurrence of disease in lady's finger plants by various inputs earthworms with cattle dung, only cattle dung, vermicompost and by chemical fertilizers

10.



11. Fig. 5 Graph showing growth and development of lady's finger plants promoted by vermicompost with earthworms, only vermicompost and those by chemical fertilizers