

**Effect of Integrated Nutrients with Liquid Organic
Product TM AGRICULTURAL on Groundnut
(*Arachis hypogaea*)**



Submitted by

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Effect of Integrated Nutrients with liquid organic product TM Agricultural on Groundnut



PROJECT SUMMARY REPORT 2011-2013

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PROJECT BACKGROUND

The present research project was designed and conducted as a part of Best Environmental Technologies Global Research Program. This project at Agricultural Research Institute, Durgapura, Jaipur was selected because of its strategic location and significant contribution to the farming community in semi arid eastern plains in **INDIA**.

The project was framed to study the efficacy of liquid organic product TM Agricultural on crop performance and yield of groundnut in semi arid eastern plain of Rajasthan, India where rain are scanty, summers are dry and very hot with mild winters with limited water resources.



Rajasthan Agricultural University was established on 1st August, 1987 by promulgation of an ordinance (#13 of 1987) which was later enacted by an Act (#39 of 1987). The University has undergone two major divisions through which the universities viz., MPUAT (Udaipur) and RAJUVAS (Bikaner) were carved out in 1999 and 2010 respectively. The SKRAU caters to the agricultural need of 21 districts out of 33 districts of Rajasthan. The University is committed to achieve excellence in the fields of education, research and extension in agriculture. Its multi-faceted activities are carried out through a network of six colleges, seven agricultural research stations and eight agricultural research sub-stations. Besides, there is a National Seed Project unit of ICAR functioning at Beechwal, with three seed farms at Beechwal, Khara and Rojari. The extension activities are carried out through 14 Krishi Vigyan Kendras and an Agricultural Technology Information Centre (ATIC).

Agricultural Research Station (ARS), Durgapura, Jaipur, comes under the S.K.

Rajasthan Agricultural University, Bikaner for the organization and management of research in all disciplines of agricultural sciences. This ARS since its inception in 1943 has come a long way, witnessing an era of state food deficits and poor farming systems to the present situation where we have enough food grain reserve.

**AGRICULTURAL RESEARCH STATION
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ARS Jaipur is the biggest research center of S. K. Rajasthan Agricultural University, Bikaner., which was established on 74.1 hectare land with laboratories, experimental farm and a few residential accommodations for the staff. About 7 hectare of land is reserved for rain-fed agricultural research, and 2.5 ha land for organic farming, which is the need of the time in the state. This station is well equipped with modern laboratories and other infrastructure facilities to conduct research in the identified thrust areas. The various laboratories include Pesticide Residue Lab, White grub & other soil Arthropods Lab, Bio-agent production Lab, Seed Technology Research Lab, Crop Physiology Lab, Soil & Plant Elemental Analysis Lab, Wheat Quality Lab, Pathology Lab, Microbiology Lab, Vermi-compost Lab, Disease forecasting unit, Plant health clinic and Post Harvest Technology Lab. This station also has some general facilities like the CIMCA (Centre for Information Management and Computer Application), Kisan Call Centre, Library & Information Centre, Workshop, etc. As an important academic activity, Academy of Agriculture, Allied Sciences and Technology (AAAST) has been established with the objectives to organize symposia, seminars and publish the research highlights. More than 100 scientists and 200 administrative, supporting and auxiliary staff members are engaged in various research activities.

Through its Research Sub-stations in the zone-IIIa the research on development and production is taken care of on mustard, turmeric, cotton, maize, sorghum, arid fruits, floriculture, etc.

To redress the existing constrains in agriculture, following disciplines, have been working through multidisciplinary approach:

Plant Breeding & Genetics	Horticulture
Agronomy	Seed Technology Research
Soil Science & Agricultural Chemistry	Breeder Seed Production
Plant Pathology	Agricultural Engineering
Entomology	Statistics
Nematology	Agricultural Economics
Physiology	Agro-meteorology
Biochemistry	

EXECUTIVE SUMMARY

A research project was taken at S K Rajasthan Agricultural University Agricultural Research Institute (ARI) at Durgapura, Jaipur from June 2011 to October 2013 to study the efficacy of organic liquid product “TM AGRICULTURAL” manufactured at BEST ENVIRONMENTAL TECHNOLOGIES INC. Edmonton, Canada.

TM Agricultural is being used in different countries around the world since 1999 for enhancing soil quality and production of different crops. Therefore, the trials were set up to study the efficacy on crops in semi arid eastern plain of Rajasthan, India where rain is scanty, summers are dry and hot and water is also limited for crops. Soils are poor in organic matter, low in organic carbon, nitrogen and medium in available phosphorus and potash. The location was taken as a benchmark to demonstrate and assess the product efficacy with an assumption that, if the product works in the scanty rainfall and dry climatic conditions, it could do well in other parts of the country also where these resources are not limited.

TM Agricultural is derived from natural and organic sources and manufactured according to USDA organic standards in Canada. The product is registered under USDA, National Organics Program (NOP) standards, by different states in USA and in other countries. It helps plants in increasing their nutrient uptake from soils and over all crop performance. It also helps in improving soil physical conditions and nutrient availability, movement and retention in soil while enhancing the soil quality.

The 3 years trials data were analyzed and compiled using standard analytical methods and statistical tools to compare the differences among treatments treated with TM Agricultural product and control treatments with and without required amounts of fertilizers. Some of the findings are listed below:

Highlights of the Findings

- Pod yield of TM treated crops were significantly higher over non-treated crops. Average yield over 3 years was increased by 435 kg per hectare over non-treated crop under the same fertilizer program.
- On an average, over 3 years period TM Ag increased pod yield by 11 % over non treated crop under same amount of fertilizer applications.
- TM alone without any fertilizers increased the pod yield by 33.5 % (1026 kg/ha) over control, which indicates the potential benefits for the organic growers.
- On an average TM treated plants had 5 more pods per plant (31%).

- Oil content in nuts was increased by 7.25% with only TM Ag application over control and 2% in TM Ag + fertilizers vs. fertilizer applied crops.
- Protein content in kernel was increased by 1.22% in TM treated crops over non-treated crop under same fertilizer application program.
- Number of active nodules per plant for fixing atmospheric nitrogen was increased by 11% and nodules weight 7% under same fertilizer program. The differences were much higher between the TM treated and non-treated crops (29% and 40% higher nodules number and weight, respectively over control crop) without fertilization.
- Higher tolerance to moisture stress was observed in TM Ag treated plants.
- TM could promote average root length of the plant increase by 12.5 per cent and weight by 39 per cent over non-treated crop under same fertilizer program.
- Soil Microbial Biomass Carbon (SMBC) in soil is increased nearly by 12 % over the corresponding non-treated crop under same amounts of fertilizer application.
- TM Ag treated plots showed higher nutrients in soil at the end of each crop season compared to the soils from non-treated plots.
- Field scale TM Agricultural application recommendations: 100 ml/acre on soil at the time of sowing, and 2 sprays on crop as foliar application @150-200 ml (depending on water volume required to spray) per acre at 3-4 leaf stage and 3 weeks after 1st foliar spray.

1.0 INTRODUCTION

Research project entitled “ *Effect of Integrated Nutrients with Liquid Natural Product ‘TM Agricultural on Kharif (summer) and Rabi (winter) Crops in Semi-arid eastern plains of Rajasthan, INDIA*” taken at ARI, Durgapura, Jaipur to find out the effect of TM Agricultural for enhancing the production and quality of groundnut. The research institute is located in an important and strategic location to demonstrate advance technologies in farming to communities in semi arid eastern plains of Rajasthan, India

The geographical setting is dominated with scanty rains and hot summers with dry and very hot weather. Water is the most limited resource in this area and soils are poor in organic matter, low in organic carbon and medium in available nutrients like nitrogen, phosphorus and potassium.

TM Agricultural product is manufactured according to USDA organic standards. It is registered under USDA, National Organics Program (NOP) standards in USA and in other countries. It helps plants in increasing their nutrient uptake from soils and improves over all crop performance by assisting the plants with higher nutrient absorption and better nutrient movement and retention in soil while enhancing the soil quality. TM Agricultural treated plants are expected to have a balance of nutrients in their tissues and grow healthier and stronger to yield better.

Being a drought prone state and having smallholdings less than 1 ha, the socio-economic status of farmers in Rajasthan state does not allow them to use advanced agricultural practices. So, TM Agricultural application may enhance the efficiency of applied fertilizers by increasing the nutrient availability, which in turn reflects the yield and better quality produce. Farmers can get higher prices for their produce by spending less money on agricultural inputs.

Organic farming system solely depend on the use of crop residues, animal manures, green manures, off farm organic waste, crop rotation, incorporating legumes and biological pest control to maintain soil productivity (Palaniappan and Annadurai 1999). The philosophy is to feed the soil rather than crops to maintain soil health and it is a means of giving back to the nature what has been taken out from it (Funtilana 1990). Therefore, the university has undertaken the project to test TM Agricultural, a certified liquid organic product. TM Agricultural is a dark brown colored liquid with a faint pungent smell of vinegar containing different amounts of macro and micro nutrients extracted in to water from plant materials. It is non hazardous under USDA, safety and environmental regulations. This project was under taken to study the efficacy on groundnut (pea nut) in 3 *Kharif* (summer) crop seasons.

OBJECTIVES

- To study the effect of TM Agricultural on plant growth, yield, oil and protein contents in kernel.
- Study the effect on soil nutrients status and soil microbial biomass.
- Transfer of technology to users for successful adoption.

2.0 MATERIALS AND METHODS

Field experiment was started in June 2011 on groundnut crop with six treatments using with and without Rhizobium culture inoculation in split plot design at ARI, Jaipur. The research farm is located at 75° 25' East longitude and 26° 06' North longitude at 427 meter above m.s.l. in Rajasthan State, India. The climate in this region is typically semi-arid characterized by extremes temperature in both summer and winter. During the summers, temperature goes as high 48°C while in winter it may fall as low as to below 5°C. The average rainfall is about 45 cm during July to September. Data on temperature, relative humidity rainfall and evaporation recorded at the farm meteorological observatory during experimentation are presented in Table-1, Table 2 and 3 below.

TABLE 1: METEOROLOGICAL DATA FOR THE CROP SEASON (KHARIF – 2011)

Month	Week No.	Date	Temp° C	R.H. (%)	Rainfall (mm)	Rat of evaporation (mm) U.S. open pan
		From – To	Max. – Min.			
June 2011	1.	18-24	37.3 – 26.4	56.3	6.0	11.0
	2.	25-1 July	33.6 – 24.9	72.2	2.6	6.1
July 2011	3.	2-8	36.2 – 26.6	58.8	0.0	8.1
	4.	9-15	33.9 – 25.4	72.6	6.0	7.5
	5.	16-22	31.8 – 24.1	81.4	16.7	3.5
	6.	23-29	31.6 – 25.2	80.0	3.5	4.4
	7.	30-5 August	34.0 – 24.3	74.4	7.6	6.0
August 2011	8.	6-12	31.2 – 24.4	82.6	3.1	4.1
	9.	13-19	29.9 – 24.0	84.9	13.7	3.2
	10.	20-26	32.4 – 23.9	79.6	7.7	3.7
	11.	27-2 Sept.	33.6 – 25.2	72.9	5.8	5.2
September 2011	12.	3-9	29.5 – 23.5	87.9	12.9	2.6
	13.	10-16	32.3 – 24.6	75.1	0.7	4.2
	14.	17-23	32.6 – 23.1	67.7	0.5	4.8
	15.	24-30	33.9 – 21.7	56.8	0.0	6.7
October 2011	16.	1-7	34.2 – 21.3	52.4	0.0	6.4
	17.	8-14	35.4 – 21.2	41.3	0.0	6.3
	18.	15-21	34.6 – 19.0	35.1	0.0	6.2

TABLE 2 : METEOROLOGICAL DATA FOR THE CROP SEASON (KHARIF – 2012)

Month	Week No.	Date	Temp° C	R.H. (%)	Rainfall (mm)	Rat of evaporation (mm) U.S. open pan
		From – To	Max. – Min.			
June 2012	1.	18-24	40.9 – 29.2	42.0	0.0	13.1
	2.	25-1 July	40.2 – 29.9	40.0	0.0	14.3
July 2012	3.	2-8	40.2 – 27.3	52.5	57.8	12.6
	4.	9-15	32.5 – 24.5	76.5	64.8	5.3
	5.	16-22	37.3 – 27.6	53.5	0.0	8.7
	6.	23-29	36.61– 28.0	60.5	0.0	6.9
	7.	30-5 August	34.5 – 25.8	61.5	6.0	6.0
August 2012	8.	6-12	31.6 – 24.2	83.5	114.2	3.1
	9.	13-19	29.9 – 24.3	83.5	53.2	2.8
	10.	20-26	28.7 – 23.9	92.0	307.8	2.4
	11.	27-2 Sept.	30.8 – 25.4	81	99.2	3.6
September 2012	12.	3-9	29.9 – 24.5	84.0	96.0	2.8
	13.	10-16	31.9 – 24.8	78.0	39.4	4.5
	14.	17-23	32.9 – 24.0	61.5	0.0	5.3
	15.	24-30	34.5– 21.9	46.5	0.0	6.2
October 2012	16.	1-7	36.2 – 21.3	37.5	0.0	6.4
	17.	8-14	35.1– 19.6	39.5	0.0	5.6
	18.	15-21	33.5 – 22.1	36.5	0.0	5.9

TABLE 3 : METEOROLOGICAL DATA FOR THE CROP SEASON (KHARIF – 2013)

Month	Week No.	Date	Temp° C	R.H. (%)	Rainfall (mm)	Rat of evaporation (mm) U.S. open pan
		From – To	Max. – Min.			
June 2011	19.	18-24	37.6 – 26.5	58.0	30.0	8.9
	20.	25-1 July	37.4-26.3	59.5	75.2	9.4
July 2011	21.	2-8	35.5-25.2	72.0	13.8	8.4
	22.	9-15	32.8-24.9	80.0	27.8	5.8
	23.	16-22	32.4-24.2	78.5	45.0	4.5
	24.	23-29	33.2-25.6	76.5	48.0	6.1
	25.	30-5 August	31.2-25.2	81.5	26.4	2.8
August 2011	26.	6-12	29.5-23.6	90.5	221.2	0.8
	27.	13-19	30.3-23.5	86.0	79.0	2.2
	28.	20-26	30.7-23.5	83.5	142.8	2.1
	29.	27-2 Sept.	32.8-23.6	73.0	0.0	5.3
September 2011	30.	3-9	34.5-23.0	59.0	0.0	6.7
	31.	10-16	36.9-25.2	53.0	1.0	6.5
	32.	17-23	34.9-24.7	63.0	30.4	6.0
	33.	24-30	32.1-23.8	76.5	15.8	5.4
October 2011	34.	1-7	31.7-23.2	70.5	0.0	5.4
	35.	8-14	33.0-22.0	66.5	1.2	5.8
	36.	15-21	34.0-20.5	45.5	0.0	4.8

Soil of experimental site was loamy sand. The initial sample was taken up to depth of 30 cm and analyzed for various chemical and physical properties using standard laboratory methods. Some important physico-chemical properties are given in table 4 below.

TABLE 4 : PHYSICO – CHEMICAL CHARACTERISTICS

pH	8.1
True density (g/cc)	2.55
Field capacity (%)	9.83
Hydraulic conductivity (cm/hr.)	6.80
Organic Carbon (%)	0.24
Wilting Point (%)	3.15
Available Nutrient (ppm)	
Nitrogen	145.27
P ₂ O ₅	24.65
K ₂ O	188.69

2.1 Treatment combinations

- T₁ : Recommended Dose of Fertilizer (RDF) without TM
- T₂ : TM + 2/3 RDF
- T₃ : TM + 1/3 RDF
- T₄ : TM + Full RDF
- T₅ : TM Agricultural only
- T₆ : Control

These treatments were applied with & without *Rhizobium* culture with a total number of 12 treatments and replicated three times in split plot design by taking culture as main plot and doses of fertilizer in sub plot. Recommended doses of NPK fertilizer i.e. 20-40-30 kg ha⁻¹ of N-P-K, respectively was applied as basal (before seeding).

TM Agricultural was sprayed @ 0.5% (5 ml per liter water) on surface of moist soil as first application at the time of sowing and second application at 30 days after germination and third at flowering stage. Groundnut CV. RG-382 was sown at a row spacing of 45 cm in June in 2011, 2012 and 2013 and harvested in the month of October every year. After 30, 45 & 70 days after seeding, plant samples were taken and sent to lab for NPK determination in tissue. Root length and number of nodules were taken at 30 and 45 days of growth stage. Rhizosphere soil samples were also taken for analysis of soil microbial biomass of carbon, bacteria & fungi counts.

Agronomic variable and yield data were recorded every year during the crop at specified intervals and yield at harvest. Laboratory analysis and statistical analysis was performed using standard analytical methods and statistical designs to test the differences among treatments using AVOVA. Soil and plant samples were taken for chemical analysis after harvest of groundnut. Kernel and plant samples were digested using nitric-perchloric

(4:1) mixture for P & K determination and Sulphuric and perchloric (9:1) mixture was used to determine N by colorimetric method using Nessler's reagent (Jackson 1973). Phosphorus was estimated by vanadomolybdate yellow colour method (Jackson 1973) and potassium was estimated using flame photometer.

Soil microbial biomass carbon was estimated by using the method given by Jenkinson and Powlson (1976) and organic carbon was determined by Walkley and Black (1934). Bacteria and Fungi populations were counted by using Topping (1938) method.

3.0 RESULTS

3.1 Three years data and interpretation

Over all growth during the entire crop seasons was better in all the TM treated crops as compared to control crops.

Number and weight of nodules: Three years pooled data revealed that the number and weight of nodules per plant were significantly higher in all TM treated treatments as compared to control. Maximum number of nodules (238.11) per plant were found in treatment T₄ (TM +RDF) followed T₂ T₃, and T₅. The highest nodule weight (433.78mg) per plant was also found in treatment T₄ (with TM) followed T₂ T₃ T₁ and T₅. Lowest weight (288.85 mg) per plant was observed in treatment T₆ (control). Application of TM Agricultural (T₄) gave significantly higher number and weight as compared to the corresponding crop without TM under same fertilizer applications.

Number and weight of groundnut pods per plant: Three years pooled data showed that all TM treated treatments gave significantly higher number and weight of pods over control. Significantly higher number (41) and weight (39.04 g) per pod were found in treatment T₄ (TM + RDF) and lowest number of pods (31) per plant and weight of pods (30.60 g) was observed in T₆ (control). Only TM treated plants produced almost equal number and weight of pods as compared to only fertilizer-applied crops.

Groundnut pod and Kernel yields: TM treated treatments gave significantly higher pod and kernel yield over the corresponding treatments with out TM application in all 3 years. Pooled data showed that treatment T₄ (TM + RDF) gave the highest pod yield (4524 kg/ha) and kernel yield (3050 kg/ha), which was significantly higher over all non-TM treated treatments. Pod yield was increased by 435 kg/ha (11%) over the non-treated crop with same amounts of fertilizer applications. Only TM treated crop gave 33.5% higher pod yield over control with no fertilizers and TM.

Treatment T₄ increased pod and kernel yields over all the treatments. The increase was 10.64,10.74,and 47.89 per cent in pod weights and 10.55,10.62 and 41.01 per cent in kernel weights over T₁ (RDF), T₅ (TM Ag only) and T₆ (control), respectively.

Oil and protein content: Maximum oil content in kernel was recorded in treatment T₄ (TM with normal fertilizer application rates) in all the three years that was significantly higher to all the treatments. The lowest oil content was found in control (T₆) in all the three years. All the TM treated treatments gave significantly higher protein content over control. TM Ag increased oil content and protein content by 7.2 and 1.5 per cent over the fertilized crops without TM application, respectively.

Soil microbial bio mass carbon (SMBC): Three years mean data of Soil microbial bio mass carbon showed that maximum SMBC (248.06 mg/ kg soil) was recorded in treatment T₄ (TM + RDF) followed by T₂ (TM + 2/3 RDF), T₅ (TM Ag only), T₃ (TM.+1/3 RDF) T₁ (RDF only) and lowest of 175.60 mg/ kg soil was found in T₆ (control).

Fungi and Bacteria: Three years data showed that maximum counts of fungi and bacteria were observed in treatment T₄ (TM + RDF) in all the three year, which was significantly higher over all non-treated crops. Treatment T₅ (TM Agricultural only) also produced significantly higher fungi and bacteria over control crop.

Table 5: Effect of TM Agricultural on Soil microbial biomass carbon in soils under Groundnut crop 2011, 2012 and 2013

Treatments	SMBC (mg/g soil) 2011	SMBC (mg/g soil) 2012	SMBC (mg/g soil) 2013	3 years Mean
RDF only	202.50	228.16	234.50	221.72
TM +2/3 RDF	228.67	232.50	237.83	233.00
TM + 1/3 RDF	229.83	230.17	236.50	232.17
TM + RDF	266.17	236.33	241.67	248.06
TM only	239.17	224.50	234.00	232.56
Control	176.33	179.83	171.83	175.60
CD (P=0.05)	6.42	4.82	2.28	

Table 6. Effect of TM Agricultural on soil bacteria and fungi under groundnut.

Treatments	Bacteria (cfu10 ⁴) g ⁻¹ soil			Fungi (cfu 10 ³ g ⁻¹)		
	2011	2012	2013	2011	2012	2013
RDF only	33.67	33.17	39.00	41.67	51.50	53.33
TM +2/3 RDF	38.00	35.50	41.17	43.33	53.00	55.33
TM + 1/3 RDF	33.50	34.50	40.17	42.50	53.50	54.33
TM + RDF	38.50	38.17	43.33	46.50	57.00	59.67
TM only	38.00	32.83	39.83	43.67	49.33	53.00
Control	22.50	25.33	27.00	32.00	37.00	39.00
CD (P=0.05)	2.49	2.34	1.77	1.37	3.96	1.69

Table 7. Effect of TM Agricultural on pod and kernel yield.

Treatments	Pod Yield Kg/Ha				Kernel Yield Kg/Ha			
	2011	2012	2013	3 years Pooled	2011	2012	2013	3 years Pooled
RDF only	4340	3996	3929	4089	3125	2597	2554	2759
TM +2/3 RDF	4501	4145	3988	4211	3241	2694	2592	2842
TM + 1/3 RDF	4369	4109	3962	4146	3146	2671	2575	2797
TM + RDF	4732	4465	4377	4524	3404	2902	2845	3050
TM only	4326	4016	3917	4085	3115	2610	2546	2757
Control	3767	3352	2458	3059	2712	2179	1598	2163
CD (P=0.05)	1.58	1.86	1.85	2.40	1.14	1.21	1.20	1.59

Table 8. Effect of TM Agricultural on Number and weight of pods.

Treatments	Number of pods per plant				Weight of pods (g) /plant			
	2011	2012	2013	3 years Pooled	2011	2012	2013	3 years Pooled
RDF only	35.17	37.83	37.17	36.72	38.33	33.93	32.89	34.09
TM +2/3 RDF	38.50	38.50	38.33	38.45	39.65	34.68	34.03	35.50
TM + 1/3 RDF	36.83	38.33	37.83	37.67	37.94	34.65	35.18	35.44
TM + RDF	41.17	40.83	40.83	40.95	47.36	38.30	37.96	39.04
TM only	37.17	37.00	39.00	37.39	40.68	35.15	34.61	35.60
Control	31.83	32.50	29.33	31.22	34.11	30.38	28.71	30.60
CD (P=0.05)	1.90	2.10	1.97	1.80	2.40	2.10	3.00	2.20

Table 9: Effect of TM Agricultural on Number and weight of Nodules /plant of Groundnut

Treatments	Number of nodules /plant				Weight of nodules/ plant (mg)			
	2011	2012	2013	3 years Pooled	2011	2012	2013	3 years Pooled
RDF only	214.33	218.50	210.33	214.39	428.17	408.38	388.57	405.7
TM +2/3 RDF	241.83	222.50	212.83	225.72	450.83	415.37	396.06	420.7
TM + 1/3 RDF	232.17	221.33	212.17	221.89	436.17	410.25	393.09	411.8
TM + RDF	260.00	232.33	222.00	238.11	473.33	424.63	406.85	433.78
TM only	214.5	222.83	214.7	216.00	412.1	409.9	388.0	403.3
Control	171.67	166.67	163.3	167.22	293.17	294.87	278.53	288.85
CD (P=0.05)	5.83	3.77	3.50	10.08	6.37	4.18	4.82	16.24

Table 10: Effect of TM Agricultural on Root length and Root weight of Groundnut

Treatments	Root length (cm)				Root weight (g/plant)			
	2011	2012	2013	3 years Means	2011	2012	2013	3 years Mean
RDF only	45.70	49.30	51.00	48.67	8.27	9.35	11.36	9.66
TM +2/3 RDF	50.00	51.25	53.67	51.64	13.05	11.25	12.33	12.21
TM + 1/3 RDF	52.20	48.60	51.83	50.88	10.12	10.65	2.33	11.03
TM + RDF	54.00	53.45	56.83	54.76	13.90	12.85	13.47	13.41
TM only	46.45	47.38	51.83	48.55	9.24	10.68	12.14	10.69
Control	35.65	38.46	44.67	39.59	7.95	8.35	8.08	8.13
CD (P=0.05)	0.35	0.48	1.20		0.36	0.48	0.55	

Table 11. Effect of TM Agricultural on protein and oil content of groundnut

Treatments	Protein %				Oil content %			
	2011	2012	2013	Mean	2011	2012	2013	Mean
RDF only (T1)	26.98	27.50	26.61	27.03	52.39	48.58	51.06	50.68
TM +2/3 RDF (T2)	27.80	27.56	27.21	27.52	53.09	51.31	51.52	51.97
TM + 1/3 RDF (T3)	27.33	27.06	26.88	27.09	51.94	50.27	51.44	51.22
TM + RDF (T4)	28.67	27.98	28.11	28.25	53.87	52.36	52.02	52.75
TM only (T5)	27.40	27.00	26.95	27.12	52.41	51.11	50.96	51.49
Control (T6)	24.61	25.63	24.75	24.99	44.71	43.72	44.19	44.21
CD (P=0.05)	0.69	1.05	0.73		0.61	2.02	0.62	

Conclusions

The three years pooled data revealed that all the TM Treated treatments gave significantly higher pod and kernel yield of groundnut over control. Treatment T₄ (TM + RDF) gave highest pod (4524 kg/ha) and kernel (3050 kg/ha) yield that was significantly higher than all the treatments.

Pod and kernel yield in normal fertilized crop (T₁) and Only TM treated crop without any fertilizers (T₅) was almost equal.

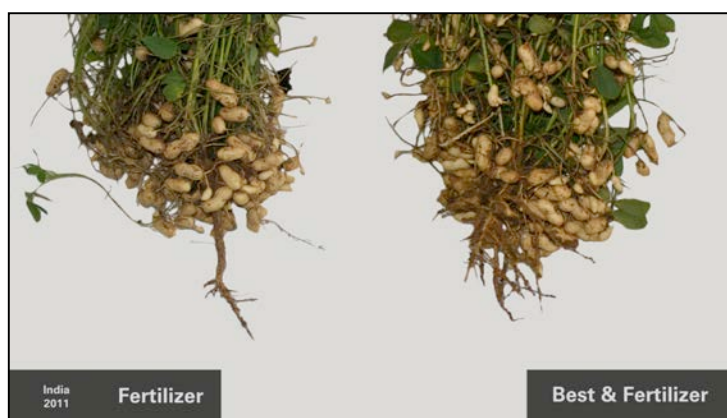
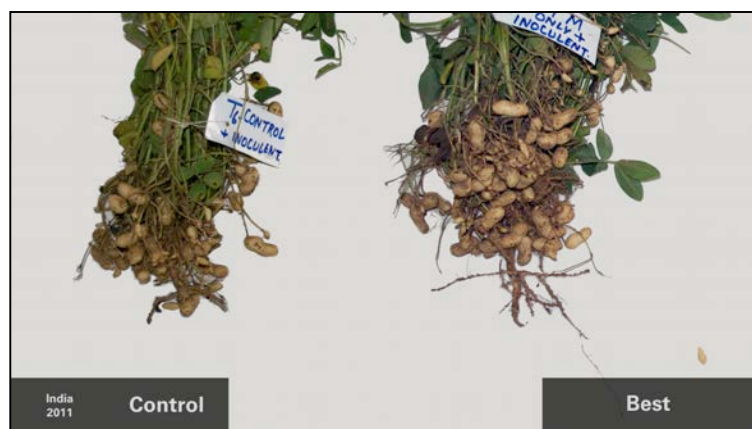
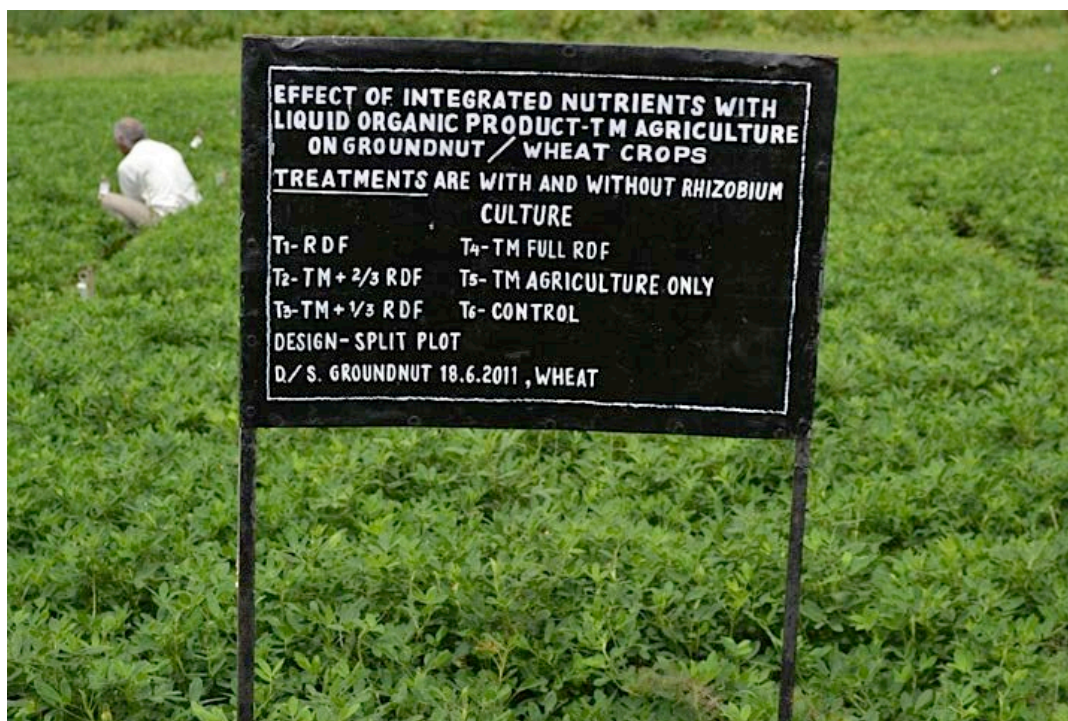
The lowest was in treatment T₆ (control).

Treatment T₄ increased pod yield over all the treatment by 10.64, 10.74, and 47.89 per cent; Kernel yield was also increased by 10.55, 10.62 and 41.01 % over T₁ (RDF), T₅ (TM Ag only) and T₆ (control), respectively.

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Field Photos



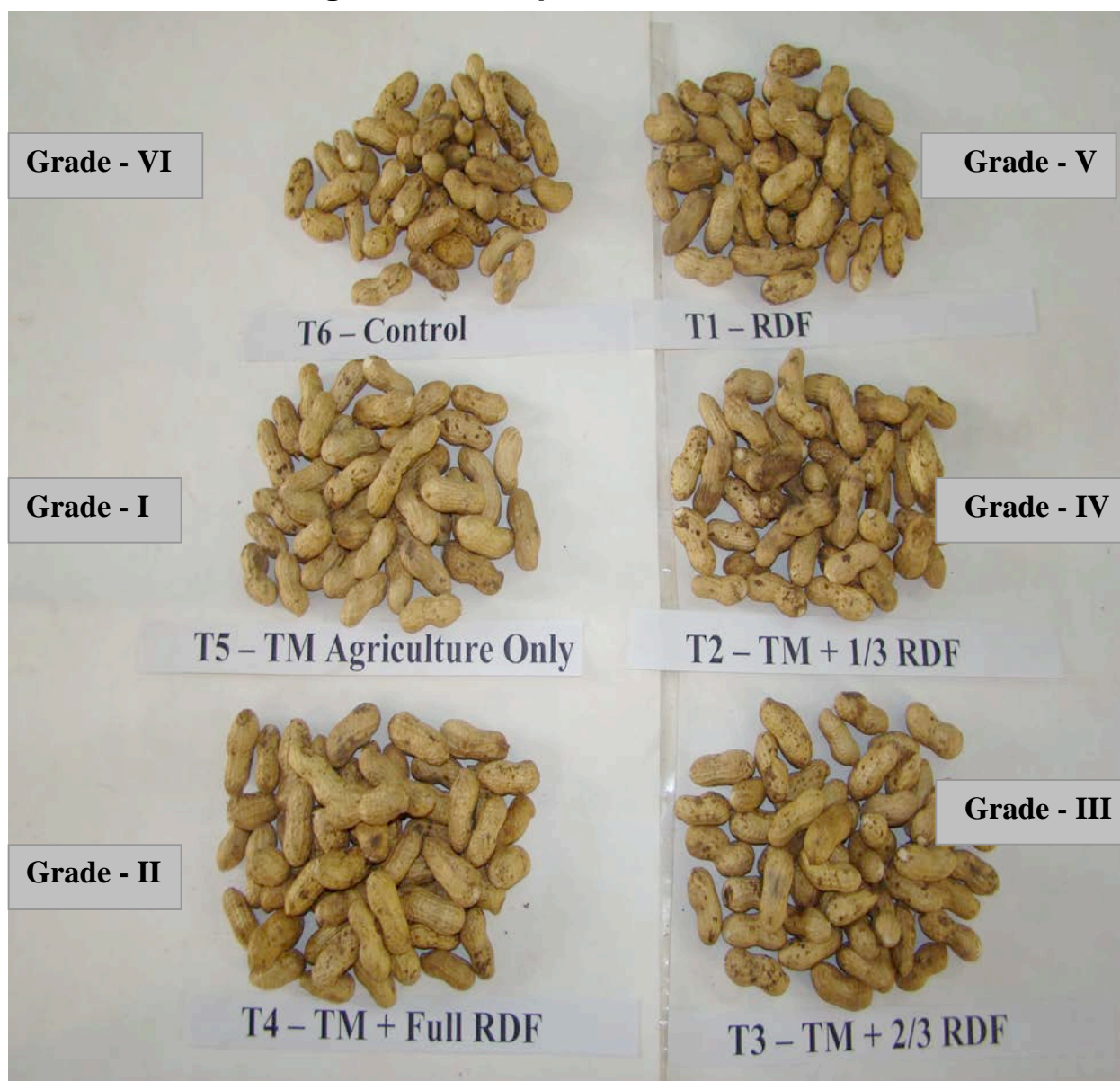


Only Fertilizers applied

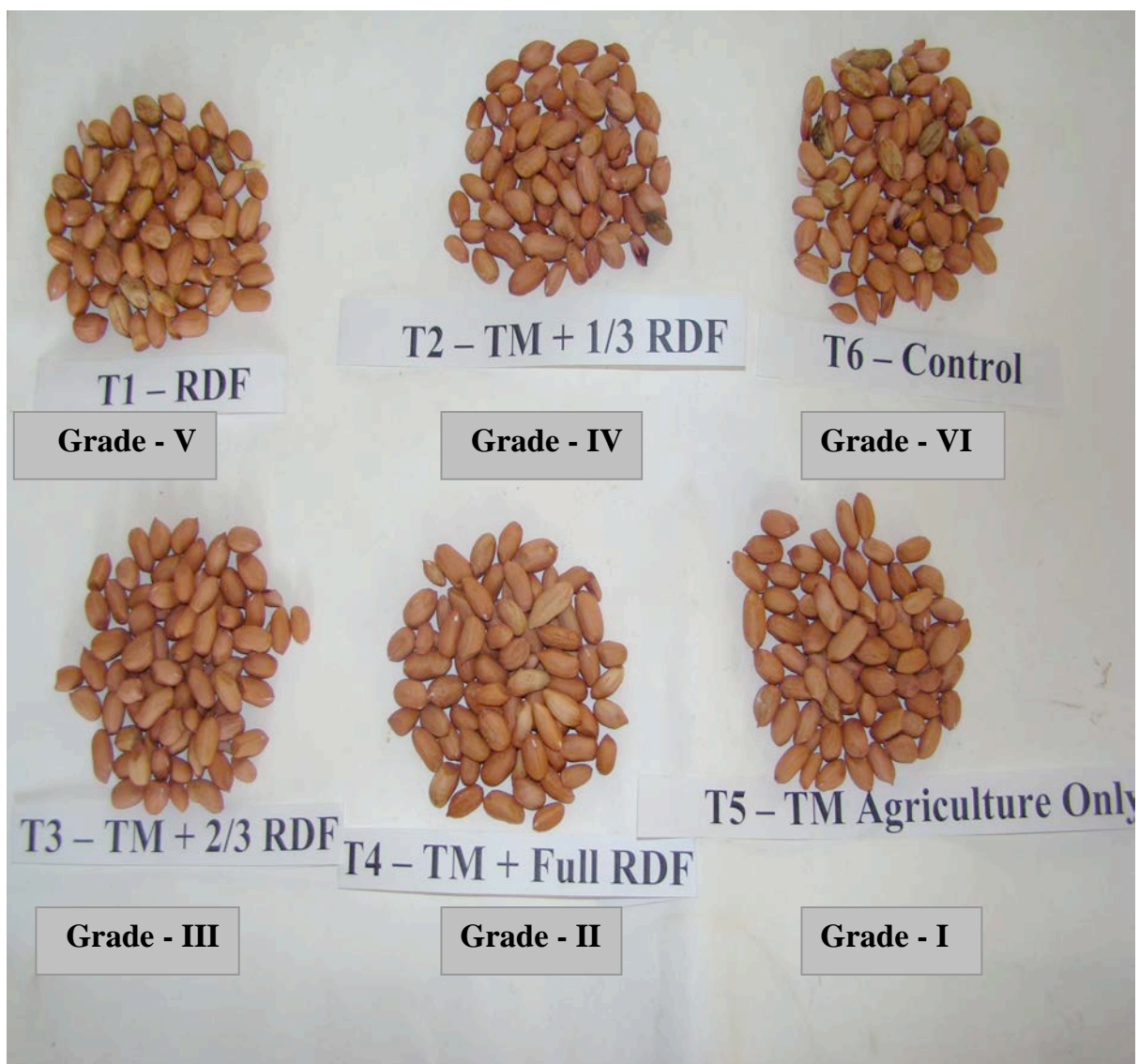


T.M + 1/3 Fertilizers applied

Grading of Pod Samples from all Treatments



Grading of Kernel Samples from all Treatments



Appendices:

ANOVA for pooled data (2011 to 2013) on pod yield, kernel, number of pods per plant, pod weight of Groundnut

Pod yield q/ha.			Number pod /plant		Wt. pods /plant (gram)		Kernel yield	
DF	MSS	VARIANCE	MSS	VARIANCE	MSS	VARIANCE	MSS	VARIANCE
Rep. - 2	75.4454	98.51	1.75423	0.10	26.68297	12.60	51.387	82.77
Culture (I) -1	13.2860	9.04x	49.84358	2.85	4.90621	<1	9.0347	9.04
Error (a)-2	0.76584		17.5157		2.114599		0.6208	
PE 6	1.704		2.5462		7.049		1.1587	
MPE 8	1.4694				5.8159		0.9992	
Tr.-5	148.6814	37.43xx	62.0057	25.40xx	44.7551	12.28xx	99.6165	36.8766
TxI -5	1.34491		1.99411	1.29	0.75094	<1	0.92798	0.34
Error(b) -20	3.97258		1.54667		0.721366		2.7014	
PE 60	2.1487		2.7387		-4.616		1.4611	
MPE 80			2.4407		-3.6428		-	

ANOVA for pooled data (2011 to 2013) on number of nodules per plant, weight of nodules, soil bacteria and soil fungi

Number of nodules/plant			Wt. nodules/plant		Fungi		Bacteria	
DF	MSS	Variance	MSS	Variance	MSS	Variance	MSS	Variance
Rep. - 2	887.02778	126.84	4442.162	7.06	395.512	145.90	93.0961	73.05
Culture(I) -1	395.34706	62.10 ^{xx}	2855.476	4.54	63.5209	14.30xx	31.4711	16.19 ^{xx}
Error (a)-2	6.99313		629.2619		2.7109	<1	1.27436	<1
PE 6	6.1572		43.841		5.018		2.1663	
MPE 8	6.3662				4.4412		1.9433	
Tr.-5	3567.6600	50.91 ^{xx}	16657.1657	91.56 ^{xx}	235.436	75.43 ^{xx}	169.0859	52.97 ^{xx}
TxI -5	22.33484	0.32	132.30418	0.75	4.8916	1.57	0.18773	0.07
Error(b) -20	70.08461		181.9242		3.12142		2.5474	
PE 60							3.4067	
MPE 80							3.1918	