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ORIGINAL ARTICLE

Effect of sowing dates, spacing and nutrient management on growth, yield and economics of groundnut (*Arachis hypogaea L*)

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ABSTRACT

A field experiment was conducted for two consecutive years during pre-kharif season of 2015 and 2016, to "Effect of date of sowing, spacing and nutrient management on Groundnut (Arachis hypogaea L) " in the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, The predicted yield was under estimated by DSSAT model for sowing at D1 and over estimated for sowing at D3 and D4. Whereas the yield from sowing at D2 was somehow w closer to simulated yield. With the application of increase in maximum temperature and minimum temperature , model showed decrease in yield in D1 sowing and Increased yield in D3 and D4 sowing and showed more or less stability in D2 sowing. However as a crop, groundnut required higher temp. during its reproductive phage , (Ideal temperature for reproductive stage is b/n 24^{0}c – 27^{0}c and Rate of pod growth will be maximum b/n 30^{0}c & 34^{0}c) even with the increase in temp the ideal temp could not be achieved during reproductive phase rather it shortened the reproductive phase in D1 sowing which decreased the yield. Whereas, in D3 and D4, increment in temp will remain in ideal temp regime for g. nut in reproductive phase and will rather hasten the pod growth and ultimately may increase the yield. However it has also the risk of touching the max temp which may have the negative effect on yield. Thus, D2 showing showed less vulnerability in terms of global warming and had the max yield without any risk. Apart from thatD3 and D4 have the possibility to face heavy pre-monsoon shower at maturity phase which could affect the ultimate yield. The return per rupee invested was maximum in the treatment D2S2N3 i. e.. Rs.1.94 and 1.96 for the year 2015 and 2016 respectively, followed by treatment D2S2N2 i. e. Rs.1.84 and Rs.1.88 for the year 2015 and 2016 respectively. Therefore considering both model and reality in future condition of Cooch behar 40 x 10 cm spacing with combination of chemical and organic sources (N3) sown at Standard MW 5(January29-February 4)

Keywords: *West Bengal, Groundnut, Date of sowing, Economics.*

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INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in India and commonly called as poor man's nut. It covers more than 40% acreage and 60% production in the country. During 2013-14, out of total oilseed production of 26.73 million tones, groundnut shared about 6.482 million tonnes (Source: Indian Oilseeds and Produce Export Promotion Council, Trade Estimates 2013-14). Therefore, share of groundnut in total oilseed production (24%) implies that, it needs some extra emphasis in order to increase its production so that it can take a pivotal position in oilseed production scenario in India. In West Bengal the total area under groundnut was 46 thousand hectare during 2005-06 (DES, India, Various, issue. 2005-06) with a production of 71 thousand tonnes. The north Bengal has better productivity (1.58 tonnes ha^{-1}) of groundnut than the average productivity of West Bengal (1.47 tonnes ha^{-1}). This fact suggests that the agro-climatic condition of *terai* zone is very much conducive for groundnut cultivation. Apart from that acidic soil of North Bengal aggravates the problem of fixation of phosphorus and lower availability of micro-nutrients like zinc, boron etc. [11]. Use of higher number of tillage in light soil of Cooch Behar is nothing but misuse of energy has been revealed by different authors. The energy savings in conservation tillage was about one – third of that in the conventional tillage system Loss of carbon in high aerated soil can be rectified by incorporation of high amount of organic manure in the form of FYM, vermicompost etc. Apart from these, Vermicompost contains more number of N-fixing,

P-solubilizing and other beneficial microbes, antibiotics, vitamins, hormones, enzymes etc. which have better effects on growth and yield of plants [3]. Therefore, options to enhance the productivity of ground nut are spacing and nutrient management under suitable date of sowing are the key. CROPGRO-simulation model V4.5 has been used by several researchers for analyzing the effect of micro-climatic variability on growth & yield of groundnut [10]. Therefore, the present experiment has been taken up with the following objectives: Keeping these facts in mind, two years field experiment will be carried out at the Research farm of Uttar Banga Krishi Viswavidyalaya during the pre-kharif season of 2015 and 2016, to study the effect of varied microclimate on Groundnut (*Arachis hypogaea L*) yield due to date of sowing, spacing and nutrient management along with impact assessment of imposed temperature variation using crop growth simulation model for the terai region of West bengal, India.

MATERIAL AND METHODS

The experiment regarding production of rock phosphate enriched vermicompost was carried out at the farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal from August to October of 2014 and 2015, respectively. The farm is situated at $26^0$19'86" N latitude and $89^0$23'53" E longitude at an elevation of 43 meters above mean sea level. The northern region of West Bengal (*terai* zone) is placed along Kalimpong hills, Kurseong hills and Bhutan hills in northern side, Assam border at the east and Bihar border on the west. It includes Siliguri subdivision of Darjeeling, entire portion of Jalpaiguri and Cooch Behar and Islampur subdivision of North Dinajpur district. The total geographical area of this zone is 1025 sq. km which occupies 13.5% of the total state area.

Experimental details:

Name of experimental design: Split- Split plot, Number of replications: 3, Main plot treatments: Date of sowing (Four) D_1: Standard MW 3(January 15-21) D_2: Standard MW 5(January29-February 4) D_3: Standard MW 7(February 12- February 18) D_4: Standard MW 9(February 26-March 4) (MW= Meteorological Week).

Spacing: S_1: 30 cm x 15 cm S_2: 40 cm x 10 cm.

Sub- Sub plot treatments: Nutrient (Three) N_1: 100% RDF(20:40:20 NPK kg/ha) N_2: rock phosphate (2%) enriched vermicompost @ 2 tonne/ha N_3: 75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne/ha.

*****Rock phosphate enriched vermicompost contains 2.61%N, 2.28% P, and 2.52% K and was prepared by adding 2.0% P_2O_5 through rock phosphate;

RESULTS AND DISCUSSION

Growth attributes:

Effect of date of sowing, spacing and nutrient management on Leaf area index (LAI) at different growth stages of groundnut

The leaf area index (LAI) of groundnut was measured on six occasions at fifteen days interval starting from30 DAS till at harvest. The dates of observations were recorded at 30,45,60,75 90 and at harvest. The data (Table 1) revealed that leaf area index was low at the early stages of crop growth and went on increasing with the increasing trend till 75 DAS and thereafter declined towards maturity, probably due to senescence of lower leaves. The pooled analysis of data as mention on the table revealed that the groundnut sowing on Standard MW 5(January29-February 4) (D_2) recorded the maximum LAI at 75DAS (6.68) followed by Standard MW 7(February 12- February 18) (D_3)(6.25) and Standard MW 3(January 15-21) (D_1) (6.23) whereas the ground nut sowing on Standard MW 9(February 26-March 4) (D_4) has the lowest LAI (5.94). The maximum LAI was recorded at 75DAS in S_2 (40 cm x 10 cm) (6.52) whereas lowest LAI was recorded in S_1 (30 cm x 15 cm)(6.03). Among the different sources of nutrients treatments the LAI was observed highest in combined application of organic and inorganic source of plant nutrients N_3**(**75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne ha^{-1}) (6.58)followed by organic treatment $\mathbf{N_2}$ **(**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (6.33)and inorganic source N_1 **(**100% RDF(20:40:20 NPK kg/ha) (5.93) .Same trend of result was observed in the individual years also. Similar trends were also registered by Ghosh *et al.* [8], Saha and Hajra [16].

Table 1: Effect of date of sowing, spacing and nutrient management on Leaf area index (LAI) at different growth stages of groundnut

Treatment	30 DAS			45 DAS			60DAS			75 DAS			90 DAS			At harvest		
Main plot (Date of planting)	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
D1	2.28	2.34	2.31	3.06	3.16	3.11	4.44	4.61	4.53	6.09	6.37	6.23	6.00	6.21	6.11	4.42	4.48	4.45
D2	2.51	2.63	2.57	3.42	3.51	3.47	4.83	4.99	4.91	6.47	6.89	6.68	6.36	6.66	6.51	4.73	4.90	4.82
D3	2.27	2.31	2.29	3.04	3.13	3.08	4.35	4.50	4.43	6.13	6.37	6.25	5.99	6.17	6.08	4.34	4.36	4.35
D4	2.02	2.02	2.02	2.94	3.00	2.98	3.85	4.07	3.96	5.88	6.00	5.94	5.79	5.77	5.78	4.07	4.01	4.03
S.Em(±)	0.056	0.081	0.065	0.031	0.036	0.024	0.215	0.311	0.262	0.196	0.161	0.167	0.273	0.169	0.203	0.107	0.047	0.065
CD (P=0.05)	0.195	0.281	0.226	0.108	0.125	0.084	NS	NS	NS	NS	0.556	NS	N/A	N/A	N/A	0.370	0.161	0.225
Sub-plot (spacing)																		
S1	2.12	2.17	2.15	2.96	3.05	2.99	4.16	4.32	4.24	5.93	6.13	6.03	5.83	5.96	5.90	4.18	4.25	4.22
S2	2.41	2.48	2.45	3.28	3.35	3.33	4.57	4.76	4.67	6.35	6.68	6.52	6.23	6.45	6.34	4.60	4.62	4.61
S.Em(±)	0.05	0.043	0.046	0.046	0.053	0.038	0.103	0.051	0.046	0.169	0.063	0.061	0.111	0.061	0.063	0.026	0.075	0.036
CD (P=0.05)	0.162	0.141	0.150	0.150	0.172	0.122	NS	0.165	0.148	NS	0.206	0.200	0.360	0.197	0.204	0.085	0.245	0.119
Sub-sub plot (nutrient management)																		
N1	2.11	2.13	2.12	2.94	2.96	2.98	4.07	4.25	4.16	5.87	5.98	5.93	5.77	5.81	5.79	4.14	4.10	4.12
N2	2.29	2.34	2.31	3.16	3.25	3.21	4.44	4.60	4.52	6.17	6.48	6.33	6.06	6.26	6.16	4.42	4.49	4.46
N3	2.41	2.49	2.45	3.25	3.39	3.29	4.59	4.78	4.69	6.39	6.76	6.58	6.27	6.54	6.41	4.60	4.71	4.66
S.Em(±)	0.065	0.06	0.061	0.064	0.087	0.061	0.105	0.144	0.123	0.093	0.118	0.067	0.098	0.143	0.084	0.037	0.084	0.055
CD (P=0.05)	0.188	0.174	0.177	0.186	0.249	0.175	0.301	0.416	0.353	0.268	0.340	0.193	0.281	0.413	0.242	0.107	0.243	0.159

Effect of date of sowing, spacing and nutrient management on crop growth rate (CGR) at different growth stages of groundnut

The crop growth rate was observed for the year 2015 and 2016 from the data (Table 2) that the crop growth rate of ground nut was in increasing trend in almost in all sampling days. The groundnut sowing on Standard MW 9(February 26-March 4) (D_4) recorded the maximum crop growth rate at 90DAS-harvest (57.616) followed by sowing at Standard MW 3(January 15-21) (D1) (56.046) and Standard MW 7(February 12- February 18) (D_3)(51.521) and whereas the ground nut sowing on Standard MW 5(January29-February 4) ($D_{2)}$ recorded the lowest crop growth rate (43.526). The pooled analysis of data (Table 3 and Fig 3) shows that the Spacing, S_2 (40 cm x 10 cm) recorded the maximum crop growth rate in all sampling days (53.398) and lowest crop growth rate was observed in the Spacing S_1(30 cm x 15 cm) (50.956). Among the nutrient treatments the maximum crop growth rate was observed in organic treatment **N_2 (**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (62.205) followed by the combination application of organic and inorganic N_3 **(**75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne ha^{-1}) (61.845) and inorganic source N_1 **(**100% RDF (20:40:20 NPK kg/ha) (32.481). Same trend of result was observed in the individual years also.

Table 2: Effect of date of sowing, spacing and nutrient management on crop growth rate (CGR) at different growth stages of groundnut

Treatment	15-30			30-45			45-60			60-75			75-90			90-AT HARVEST		
Main plot (Date of planting)	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
D1	5.10	5.46	5.28	5.87	5.08	5.48	13.83	14.84	14.34	83.76	87.09	85.43	92.47	95.61	95.61	54.37	57.72	56.05
D2	5.52	5.54	5.53	5.60	5.80	5.70	17.60	18.09	17.84	82.60	85.91	84.25	101.06	108.92	108.92	46.57	40.48	43.53
D3	5.33	5.37	5.35	5.02	5.12	5.07	13.46	13.84	13.65	82.53	85.95	84.24	90.35	97.67	97.67	54.15	48.89	51.52
D4	5.15	5.17	5.16	4.60	5.26	4.93	14.33	14.22	14.27	73.92	77.39	75.66	90.26	88.25	88.25	50.94	64.29	57.62
S.Em(±)	0.165	0.190	0.041	0.166	0.128	0.071	0.513	0.593	0.544	1.540	1.552	1.544	6.560	4.850	4.850	8.503	6.783	6.719
CD (P=0.05)	N/A	N/A	0.140	0.573	0.440	0.245	1.771	2.046	1.877	5.316	5.355	5.328	N/A	N/A	N/A	N/A	N/A	N/A
Sub-plot (spacing)																		
S1	4.87	5.03	4.95	5.43	5.53	5.48	13.06	13.34	13.20	73.25	76.63	74.94	97.84	101.11	101.11	49.47	52.45	50.96
S2	5.69	5.74	5.71	5.11	5.10	5.11	16.55	17.15	16.85	88.15	91.54	89.85	89.23	94.12	94.12	53.55	53.25	53.40
S.Em(±)	0.102	0.088	0.037	0.159	0.178	0.128	0.231	0.271	0.235	1.045	1.047	1.046	2.199	1.837	1.837	4.046	4.268	4.090
CD (P=0.05)	0.333	0.285	0.122	N/A	N/A	N/A	0.754	0.884	0.767	3.405	3.409	3.408	7.162	5.983	5.983	N/A	N/A	N/A
Sub-sub plot (nutrient management)																		
N1	4.43	4.58	4.50	4.84	4.67	4.76	9.93	10.51	10.22	71.56	74.94	73.25	102.58	104.21	104.21	29.36	35.60	32.48
N2	4.43	5.70	5.67	5.37	5.34	5.35	14.57	15.13	14.85	82.99	86.37	84.68	88.81	94.43	94.43	63.09	61.32	62.21
N3	4.43	5.87	5.82	5.60	5.93	5.77	19.92	20.10	20.01	87.56	90.95	89.26	89.22	94.19	94.19	62.08	61.62	61.85
S.Em(±)	0.085	0.095	0.051	0.138	0.215	0.143	0.344	0.362	0.337	1.094	1.092	1.093	2.121	1.471	1.471	4.018	4.433	3.891
CD (P=0.05)	0.245	0.273	0.146	0.398	0.621	0.413	0.990	1.044	0.972	3.153	3.147	3.150	6.112	4.237	4.237	11.577	12.773	11.211

Effect of date of sowing, spacing and nutrient management on Number of Nodule at different growth stages of groundnut

It was clear from the (table 3), that number of nodules varied from treatment to treatment and with the age of crop significantly. Number of nodules increased continuously and attained a maximum value at 60 days after sowing, which considered as maximum nodulation stage for groundnut. The number of nodules was observed on 2015 and 2016 from the data (Table 3) revealed that Standard MW 5(January29-February 4) ($D_{2)}$ recorded maximum number of number of nodules at maximum nodulation stage (237.229) followed by sowing at Standard MW 3(January 15-21) (D_1) (229.24)and Standard MW 7(February 12- February 18) (D_3)(224.719) and lowest number of nodules was observed on Standard MW 9(February 26-March 4) (D_4) sowing date (213.367). The Spacing, S_2 (40 cm x 10 cm) performing better in all sampling days (233.563) than the Spacing S_1 (30 cm x 15 cm) (218.715). The number of nodules among the nutrient treatments was recorded maximum at maximum nodulation stage in the combination application of organic and inorganic N_3 **(**75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0.5 tonne ha^{-1}) (245.945)followed by organic treatment **N_2(**rock phosphate (2%) enriched vermicompost @2 tonne ha^{-1}) (232.075) and lowest number of nodules was observed in inorganic source N_1 **(**100% RDF(20:40:20 NPK kg/ha) (200.396). [4, 5, 17] Individual years also gave similar trend of result.

Table 3: Effect of date of sowing, spacing and nutrient management on Number of Nodule at different growth stages of groundnut

Treatment	30 DAS			45 DAS			60DAS			75 DAS			90 DAS		
Main plot (Date of planting)	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
D1	92.39	98.20	95.30	121.09	123.09	122.09	177.15	180.15	178.65	166.74	169.74	168.24	114.15	116.82	115.49
D2	97.39	104.94	101.17	128.31	130.31	129.31	188.40	191.40	189.90	172.65	175.65	174.15	121.70	124.37	123.04
D3	87.95	93.21	90.58	116.24	118.24	117.24	174.14	177.14	175.64	163.08	166.08	164.58	109.70	112.37	111.04
D4	84.75	92.27	88.51	113.93	115.93	114.93	166.97	169.97	168.47	156.53	159.53	158.03	106.00	108.66	107.33
S.Em(±)	2.174	1.299	1.312	2.249	2.190	2.239	1.309	1.289	1.298	1.871	1.869	1.530	2.214	2.202	1.907
CD (P=0.05)	7.502	4.485	4.530	7.763	7.661	7.762	4.519	4.419	4.515	6.457	6.446	1.828	7.642	7.632	4.819
Sub-plot (spacing)															
S1	86.24	93.26	89.75	113.69	115.69	114.69	160.12	163.12	161.62	158.16	161.16	159.66	109.90	112.56	111.23
S2	95.00	101.06	98.03	126.09	128.09	127.09	193.21	196.21	194.71	171.34	174.34	172.84	115.88	118.55	117.22
S.Em(±)	1.649	6.005	1.671	2.565	2.615	2.586	2.025	2.125	2.045	2.185	2.171	1.820	0.559	0.548	0.279
CD (P=0.05)	5.372	6.005	5.443	8.253	8.323	8.302	6.596	6.496	6.576	7.116	7.105	6.729	1.821	1.813	0.910
Sub-sub plot (nutrient management)															
N1	64.80	72.33	68.57	82.51	84.21	83.51	144.46	147.46	145.96	148.86	151.86	150.36	105.71	108.37	107.04
N2	100.92	107.11	104.02	135.39	137.39	136.39	186.45	189.45	187.95	168.41	171.41	169.91	114.85	117.52	116.19
N3	106.14	112.03	109.09	141.78	143.78	142.78	199.09	202.09	200.59	176.98	179.98	178.48	118.11	120.77	119.44
S.Em(±)	1.631	0.956	1.149	1.386	1.346	1.376	2.240	2.140	2.220	1.765	1.745	1.724	1.048	1.128	0.524
CD (P=0.05)	4.699	2.755	3.311	3.994	3.794	3.981	6.454	6.354	6.412	5.086	5.076	4.962	3.020	3.120	1.510

Effect of date of sowing, spacing, nutrient management on 100-kernel weight (g) , 100-pod weight (g), and shelling outturn % of groundnut

Effect of date of sowing, spacing, nutrient management on 100-kernel weight (g)

Pooled data revealed that 100-kernel weight (g) (table 4) recorded the maximum in the Standard MW 5(January29-February 4) ($D_{2)}$ (54.68 g) followed by sowing at Standard MW 3(January 15-21) (D_1) (49.72 g) and Standard MW 7(February 12- February 18) (D_3)(47.59 g) and whereas the ground nut sowing on Standard MW 9(February 26-March 4) (D_4) has the lowest 100-kernel weight (g)(46.31 g). The pooled analysis of data (Table 7 and Fig 7) shows that the Spacing, S_2 (40 cm x 10 cm) recorded the maximum100-kernel weight (g)$_{)}$(51.465)and lowest 100-kernel weight (g)$_{)}$ was observed in the Spacing S_1(30 cm x 15 cm) (47.692). Among the nutrient treatments100-kernel weight (g) recorded the maximum in N_3 (75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne ha^{-1}) (53.575 g)followed by **N_2(**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (51.596 g) and was observed in N_1 **(**100% RDF(20:40:20 NPK kg/ha) (43.564g). Dayal and Agarwal [6], Babalad [2], Enyi [7], Jaswal and Gupta [9], Rahman and Rahman [13], Ghosh *et al.* [8], and Tiwari *et al.* [18] also reported similar result in different crops. Attarde et al. [1] also reported that different sowing dates in summer season significantly influence the 100 kernel weight.

Effect of date of sowing, spacing and nutrient management on 100-pod weight (g)

Pooled data revealed that 100-pod weight (g) recorded the maximum in the Standard MW 5(January29-February 4) ($D_{2)}$ (85.118g) followed by sowing at Standard MW 3(January 15-21) (D_1) (80.916g) and Standard MW 7(February 12- February 18) (D_3)(78.857g) and whereas the ground nut sowing on Standard MW 9(February 26-March 4) (D_4) has the lowest 100-pod weight (g) (75.099g). The pooled analysis of data (Table 7 and Fig 7) shows that the Spacing, S_2 (40 cm x 10 cm) recorded the maximum 100-pod weight (g) (81.888)and lowest 100-pod weight (g) was observed in the Spacing S_1(30 cm x 15 cm) (78.107). Among the nutrient treatments 100-pod weight (g) recorded the maximum in N_3 **(**75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0.5 tonne ha^{-1}) (85.914g)followed by **N_2 (**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (83.56g) and lowest was observed in N_1 **(**100% RDF(20:40:20 NPK kg/ha) (70.519). Ghosh *et al.* [8] reported similar result.

Effect of date of sowing, spacing and nutrient management on shelling outturn %

Pooled data revealed that shelling outturn %recorded the maximum in the Standard MW 5(January29-February 4) ($D_{2)}$ (63.925%) followed by sowing at Standard MW 9(February 26-March 4) (D_4 (61.941%) and) Standard MW 3(January 15-21) (D1) (61.467%) and whereas the ground nut sowing on Standard MW 7(February 12- February 18) (D_3)has the lowest shelling outturn % (60.435%). The pooled analysis of data shows that the Spacing, S_2 (40 cm x 10 cm) recorded the maximum shelling outturn %(62.745%)and lowest shelling outturn %was observed in the Spacing S_1(30 cm x 15 cm) (61.139%). Among the nutrient treatments shelling outturn %recorded the maximum inN_3 **(**75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne ha^{-1}) (62.211%) followed by N_1 **(**100% RDF (20:40:20 NPK kg/ha) (61.95%) and and lowest was observed **N_2 (**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (61.665%). Similar observation also found by Attarde *et al*. [1] who observed sowing in summer season significantly influenced the shelling per cent.

Effect of date of sowing, spacing and nutrient management on pod yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index (%) of groundnut

Effect of date of sowing, spacing and nutrient management on pod yield (kg ha^{-1})

Pooled analysis of data (table 5) of two years studies showed that highest pod yield was observed in the Standard MW 5(January29-February 4) ($D_{2)}$ (2,214.28kg ha^{-1}) followed by sowing at Standard MW 3(January 15-21) (D_1) (2,145.50 kg ha^{-1}) and Standard MW 7(February 12- February 18) (D_3)(2,127.06kg ha^{-1}) and whereas the ground nut sowing on Standard MW 9(February 26-March 4) (D_4) recorded the lowest pod yield (2,006.61kg ha^{-1}). Among the spacing, S_2 (40 cm x 10 cm) recorded the maximum pod yield (2,170.47 kg ha^{-1})and lowest pod yield was observed in the Spacing S_1(30 cm x 15 cm) (2,076.25 kg ha^{-1}) Among the nutrient treatments pod yield recorded the maximum in N_3**(**75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne ha^{-1}) (2,267.54 kg ha^{-1})followed by **N_2 (**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (2,188.58 kg ha^{-1}) and lowest was observed in N_1 **(**100% RDF(20:40:20 NPK kg/ha) (1,913.96 kg ha^{-1}). Manzur *et al.* [12], Rasal *et al.* [15], Raj *et al.* [14], Ghosh *et al.* [8], Saha and Hajra [16] and a number of authors experienced the higher pod yield of groundnut and other crops due to application of rock phosphate enriched compost over chemical fertiliser alone.

Effect of date of sowing, spacing and nutrient management on haulm yield (kg ha^{-1})

From pooled analysis as mentioned in (table 5), it was observed that haulm yield (kg ha^{-1}) recorded the maximum in the Standard MW 7(February 12- February 18) (D_3) (3,296.66 kg ha^{-1})followed by sowing at Standard MW 3(January 15-21) (D_1) (3,278.48 kg ha^{-1}) and Standard MW 9(February 26-March 4) (D_4) (3,247. kg $ha^{-1)}$94and and whereas the ground nut sowing on Standard MW 5(January29-February 4) ($D_{2)}$has the lowest the haulm yield (kg ha^{-1}) (3,243.65 kg ha^{-1}). The spacing, S_2 (40 cm x 10 cm) recorded the maximum haulm yield (3,270.43kg ha^{-1})and lowest haulm yield was observed in the Spacing S_1(30 cm x 15 cm) (3,262.93kg ha^{-1}) Among the nutrient treatments haulm yield recorded the maximum N_1 **(**100% RDF(20:40:20 NPK kg/ha) (3,351.28kg ha^{-1}) followed by **N_2 (**rock phosphate (2%) enriched vermicompost @2tonne ha^{-1}) (3,275.52kg ha^{-1}) and lowest was observed in N_3 (75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0.5 tonne ha^{-1}) (3,173.23kg ha^{-1})

Effect of date of sowing, spacing and nutrient management on harvest index (%)

Harvest index(%) for the year 2015 and 2016 from the data (table 5) , shows that sowing on Standard MW 5(January29-February 4) ($D_{2)}$ (40.527%) recorded the highest harvest index followed by sowing at Standard MW 3(January 15-21) (D_1) (39.50 %) and Standard MW 7(February 12- February 18) (D_3) (39.17 %) which are at par with each other. whereas the ground nut sowing on Standard MW 9(February 26-March 4) (D_4) recorded the lowest harvest index (38.26 %). The spacing, S_2 (40 cm x 10 cm) recorded the maximum harvest index (39.828%) and lowest harvest index was observed in the Spacing S_1 (30 cm x

15 cm) (38.907%). Among the nutrient treatments harvest index recorded the maximum in N_3 (75% of recommended dose of RDF + rock phosphate (2%) enriched vermicompost @ 0 .5 tonne ha^{-1}) (41.746%) followed by **N_2 (**rock phosphate (2%) enriched vermicompost @ 2 tonne ha^{-1}) (40.039%) and lowest harvest index was observe in N_1 **(**100% RDF(20:40:20 NPK kg/ha) (36.318)

Effect of date of sowing, spacing and nutrient management Economics of groundnut

Economics of groundnut for the year 2015 and 2016 from the (table 6).

Net returns (Rs. ha^{-1})

Among the treatments the net returns of Rs.1, 79767 ha^{-1} in the year 2015 and Rs.80851 ha^{-1}in the year 2016 was recorded maximum in the treatment D2S2N3 followed by the net returns of Rs.74688 ha^{-1} in the year 2015 and Rs.76355 ha^{-1}in the year 2016 was recorded in the treatment D2S2N2.

Return per rupee invested (Rs.)

The return per rupee invested was maximum in the treatment D2S2N3 i. e. Rs.1.94 and 1.96 for the year 2015 and 2016 respectively, followed by treatment D2S2N2 i. e. Rs.1.84 and Rs.1.88 for the year 2015 and 2016 respectively.

Table 4: Effect of date of sowing, spacing and nutrient management on, 100-kernel weight (g) ,100-pod weight (g)and shelling outturn %of groundnut

Treatment	100-kernel weight (g)			100-pod weight(g)			shelling outturn %		
Main plot (Date of planting)	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
D1	48.91	50.54	49.73	48.91	50.54	49.73	48.91	50.54	49.73
D2	53.79	55.57	54.68	53.79	55.57	54.68	53.79	55.57	54.68
D3	46.71	48.47	47.59	46.71	48.47	47.59	46.71	48.47	47.59
D4	45.33	47.28	46.31	45.33	47.28	46.31	45.33	47.28	46.31
S.Em(±)	**0.835**	**0.497**	**0.482**	**0.835**	**0.497**	**0.482**	**0.835**	**0.497**	**0.482**
CD (P=0.05)	**2.880**	**1.715**	**1.663**	**2.880**	**1.715**	**1.663**	**2.880**	**1.715**	**1.663**
Sub-plot (spacing)									
S1	46.38	49.00	47.69	77.28	78.94	78.11	60.15	62.13	61.14
S2	50.99	51.93	51.47	80.91	82.86	81.89	62.94	62.63	62.75
S.Em(±)	**0.511**	**0.418**	**0.240**	**0.376**	**0.369**	**0.266**	**0.596**	**0.621**	**0.253**
CD (P=0.05)	**1.665**	**1.362**	**0.782**	**1.224**	**1.202**	**0.867**	**1.942**	**N/A**	**0.825**
Sub-sub plot (nutrient management)									
N1	42.72	44.40	43.56	69.50	71.53	70.52	61.67	62.24	61.95
N2	50.67	52.52	51.60	82.74	84.38	83.56	61.14	62.22	61.67
N3	52.67	54.47	53.58	85.04	86.79	85.91	61.81	62.68	62.21
S.Em(±)	**0.479**	**0.357**	**0.205**	**0.672**	**0.485**	**0.405**	**0.740**	**0.619**	**0.407**
CD (P=0.05)	**1.379**	**1.028**	**0.592**	**1.935**	**1.397**	**1.167**	**N/A**	**N/A**	**N/A**

Table 5: Effect of date of sowing, spacing and nutrient management on pod yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index(%)of groundnut

Treatment	Pod yield(kg ha^{-1})			Haulm yield(kg ha^{-1})			Harvesting index(%)		
Main plot (Date of planting)	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
D1	2,126.83	2,164.06	2,145.50	3,255.42	3,301.48	3,278.48	39.46	39.55	39.51
D2	2,186.00	2,242.28	2,214.28	3,238.57	3,248.67	3,243.65	40.25	40.81	40.53
D3	2,106.11	2,147.56	2,127.06	3,268.74	3,324.53	3,296.66	39.14	39.21	39.17
D4	1,974.06	2,038.67	2,006.61	3,152.31	3,343.53	3,247.94	38.72	37.81	38.26
S.Em(±)	**15.489**	**22.050**	**13.890**	**18.102**	**22.480**	**9.792**	**0.193**	**0.221**	**0.128**
CD (P=0.05)	**53.458**	**76.104**	**47.939**	**62.476**	**N/A**	**33.795**	**0.667**	**0.763**	**0.442**
Sub-plot (spacing)									
S1	2,044.19	2,107.94	2,076.25	3,204.98	3,320.83	3,262.93	39.03	38.79	38.91
S2	2,152.31	2,188.33	2,170.47	3,252.55	3,288.27	3,270.43	39.75	39.90	39.83
S.Em(±)	**8.177**	**8.469**	**7.228**	**10.670**	**16.340**	**9.804**	**0.133**	**0.192**	**0.127**
CD (P=0.05)	**26.635**	**27.584**	**23.544**	**34.755**	**N/A**	**N/A**	**0.433**	**0.626**	**0.413**
Sub-sub plot (nutrient management)									
N1	1,881.42	1,946.08	1,913.96	3,334.55	3,367.98	3,351.28	36.04	36.60	36.32
N2	2,163.92	2,212.96	2,188.58	3,256.88	3,294.11	3,275.52	39.90	40.18	40.04
N3	2,249.42	2,285.38	2,267.54	3,094.86	3,251.57	3,173.23	42.23	41.26	41.75
S.Em(±)	**19.327**	**19.559**	**15.994**	**19.682**	**18.429**	**16.467**	**0.288**	**0.264**	**0.239**
CD (P=0.05)	**55.690**	**56.359**	**46.085**	**56.712**	**53.103**	**47.448**	**0.831**	**0.760**	**0.687**

Table 6: Effect of date of sowing, spacing and nutrient management on Economics of groundnut

Treatment	Cost of cultivation (Rs.ha^{-1})		Cost of treatment (Rs.ha^{-1})		Total cost of cultivation (Rs.ha^{-1})		Yield (Kg ha^{-1})		Gross return (Rs.ha^{-1})		Net return (Rs.ha^{-1})		Return per rupee invested (Rs)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
D1S1N1	38570	38570	2822	2822	41392	41392	1854	1921	92700	96033	51308	54641	1.24	1.32
D1S1N2	38570	38570	2000	2000	40570	40570	2134	2187	106700	109367	66130	68797	1.63	1.70
D1S1N3	38570	38570	2621	2621	41191	41191	2226	2246	111300	112300	70109	71109	1.70	1.73
D1S2N1	38570	38570	2822	2822	41392	41392	1969	2000	98433	100017	57041	58625	1.38	1.42
D1S2N2	38570	38570	2000	2000	40570	40570	2254	2288	112700	114383	72130	73813	1.78	1.82
D1S2N3	38570	38570	2621	2621	41191	41191	2324	2342	116217	117117	75026	75926	1.82	1.84
D2S1N1	38570	38570	2822	2822	41392	41392	1908	2060	95400	103017	54008	61625	1.30	1.49
D2S1N2	38570	38570	2000	2000	40570	40570	2187	2210	109367	110500	68797	69930	1.70	1.72
D2S1N3	38570	38570	2621	2621	41191	41191	2226	2303	111275	115167	70084	73976	1.70	1.80
D2S2N1	38570	38570	2822	2822	41392	41392	2070	2100	103517	105017	62125	63625	1.50	1.54
D2S2N2	38570	38570	2000	2000	40570	40570	2305	2339	115258	116925	74688	76355	1.84`	1.88
D2S2N3	38570	38570	2621	2621	41191	41191	2419	2441	120958	122042	79767	80851	1.94	1.96
D3S1N1	38570	38570	2822	2822	41392	41392	1867	1944	93350	97217	51958	55825	1.26	1.35
D3S1N2	38570	38570	2000	2000	40570	40570	2032	2107	101600	105350	61030	64780	1.50	1.60
D3S1N3	38570	38570	2621	2621	41191	41191	2206	2260	110300	113000	69109	71809	1.68	1.74
D3S2N1	38570	38570	2822	2822	41392	41392	1964	1987	98200	99367	56808	57975	1.37	1.40
D3S2N2	38570	38570	2000	2000	40570	40570	2254	2267	112683	113333	72113	72763	1.78	1.79
D3S2N3	38570	38570	2621	2621	41191	41191	2314	2320	115692	116000	74501	74809	1.81	1.82
D4S1N1	38570	38570	2822	2822	41392	41392	1692	1767	84617	88350	43225	46958	1.04	1.13
D4S1N2	38570	38570	2000	2000	40570	40570	2068	2132	103400	106617	62830	66047	1.55	1.63
D4S1N3	38570	38570	2621	2621	41191	41191	2130	2157	106500	107850	65309	66659	1.59	1.62
D4S2N1	38570	38570	2822	2822	41392	41392	1727	1788	86342	89417	44950	48025	1.09	1.16
D4S2N2	38570	38570	2000	2000	40570	40570	2077	2174	103850	108700	63280	68130	1.56	1.68
D4S2N3	38570	38570	2621	2621	41191	41191	2150	2213	107500	110667	66309	69476	1.61	1.69

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