

Original Research Article

Growth, yield and quality of *Rabi* groundnut (*Arachis hypogaea* L.) as influenced by sources of calcium and sulphur under different site specific nitrogen management in rice-groundnut cropping system

1. **ABSTRACT**

2. **Background:** The injudicious and imbalanced fertilizer use under the existing farming
3. system has promoted nutrient mining and development of soil acidity that necessitates
4. the adoption of amelioration methods and balanced use of nutrients especially nitrogen (N).
5. There is lack of information on effects of various sources of calcium and sulphur in
6. groundnut along with balanced nitrogen management which needs to be addressed.
7. **Methods:** A field experiment was carried out during 2020-21 and 2021-22 at Odisha
8. University of Agriculture and Technology, Bhubaneswar, Odisha, [India](#) to study the
9. growth, yield and quality parameters of groundnut as affected by site specific nitrogen
10. management in rice and various sources of calcium and sulphur in groundnut. The
11. experiment was laid out in split plot design with six main plot treatments i.e. Soil
12. test based nitrogen ([STBN](#)) (100 kg N/ha), 75% N through ~~soil test based nitrogen~~ ([STBN](#)) +
13. 25% N through [farmyard manure](#) (FYM), 75% N through STBN + 25% N through vermicompost, N @
14. 20 kg at basal and at [leaf color chart](#) (LCC) < 3, N @ 20 kg at basal and at [chlorophyll value determined by soil plant analysis development](#) (SPAD) < 35 and no nitrogen to
15. rice during *Kharif* and three sub plot treatments i.e. lime @ 0.2 LR, gypsum @ 250
16. kg/ha and lime @ 0.2 LR + gypsum @ 250 kg/ha to groundnut during *Rabi* each in three
17. replications.
18. **Result:** Application of 75 % N through STBN + 25 % N through vermicompost to
19. preceding rice and lime @ 0.2 LR + gypsum @ 250 kg/ha to groundnut crop resulted in
20. highest plant height at harvest, number of nodules per plant and dry matter
21. accumulation at harvest. Yield attributing characters like pods/plant, kernel/pod and
22. 100 - pod weight of groundnut were highest due to application of 75 % N through STBN
23. + 25 % N through vermicompost to preceding rice (17.86, 1.87 and 67.2 g, respectively)
24. followed by 75 % N through STBN + 25 % N through FYM. Application of lime @ 0.2
25. LR + gypsum @ 250 kg/ha to groundnut recorded more pods/plant (16.86), kernels/pod
26. (1.78) and 100 - pod weight (66.39 g). The treatment receiving 75 % N through STBN

Comment [E1]: Each abbreviation needs to be explained at its first appearance in text.

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The abstract should be concise and informative. It should not exceed 300 words in length.

27. + 25 % N through vermicompost in rice and application of lime @ 0.2 LR + gypsum @
28. 250 kg/ha to groundnut resulted significantly maximum pod yield (2,596 kg/ha and
29. 2,291 kg/ha), haulm yield (4,554 kg/ha and 4,343 kg/ha) and harvest index (36.30 %
and
30. 34.38 %) in groundnut. Oil yield (682.2 kg/ha) in groundnut was recorded highest in
31. the treatment lime @ 0.2 LR + gypsum @ 250 kg/ha followed by only gypsum @ 250
32. kg/ha application to groundnut. Similarly, application of lime @ 0.2 LR + gypsum @
33. 250 kg/ha to groundnut recorded highest protein yield (424.6 kg/ha).

34. **Keywords:** Pod yield, lime, gypsum, vermicompost

35. INTRODUCTION

36. Rice-groundnut cropping system is a major system followed in Odisha owing to its
37. versatility in meeting both food security and oil needs thereby maintaining the soil
38. health through biological nitrogen fixation. But farmers are routinely applying more
nitrogen (N)
39. fertilizer or blanket dose than a crop can use without considering the nutrient supply
40. capacity of the soil and crop need often resulting in low N use efficiency and
41. deterioration of soil health (Dobermann & White, 1998). Thus, fertilizer N
42. recommendations must be based on the crop demand and supply capacity of the soil.
43. Groundnut is an important edible oilseed crop that prefers mostly neutral pH. But most
44. of the soils in Odisha are red sandy, red loamy and lateritic soils which are generally
45. acidic and deficient in organic matter, N, calcium (Ca), phosphorus (P), molybdenum
(Mo) and boron (B). Therefore, there lies a
46. production gap due to various constraints such as non-availability of irrigated
47. conditions, imbalance use of nutrients, soil acidic conditions etc. The potential can be
48. increased by amelioration of soil acidity by raising pH by adding suitable quantity of
49. lime and proper balanced use of nutrients. Also, the farmers are confined mostly in
50. NPK fertilizers thus neglecting sulphur application which is important for oil synthesis
51. and uptake of various macro and micronutrients in groundnut (Singh, 1999). Gypsum
52. is a soluble source of calcium and sulphur, therefore, readily available to the
53. developing pods. Sulphur and calcium applied together are considered to be
important
54. in the pod zone for the development of pegs (Geethalakshmi and Loudurgraj, 1998).
55. Applying lime in combination with gypsum would bring more Ca and/or magnesium
(Mg) further
56. down the soil profile (Shamshuddin and Ismail, 1995), thus alleviating to some extent
57. subsoil acidity. Lime application along with integrated nutrient management is often
58. recommended to increase the phyto-availability of essential nutrients and ameliorate
59. the other acidity-induced fertility constraints on such soils (Kumar et al., 2012). Thus,
60. keeping in view the above an efficient combination of various site specific nitrogen
61. management practices in rice along with sources of calcium and sulphur to groundnut
62. were followed to study the growth, yield and quality traits in groundnut.

Comment [E3]: Manuscript structure

The text, excluding the abstract, if required, can be divided into numbered sections with brief headings. Starting from introduction with section 1. Subsections should be numbered (for example 2.1 (then 2.1.1, 2.1.2, 2.2, etc.), up to three levels.

Comment [E4]: The entire text needs to be justified.

.....in Odisha, India

Comment [E5]: References must be listed at the end of the manuscript and numbered in the order that they appear in the text. Every reference referred in the text must also present in the reference list and vice versa. In the text, citations should be indicated by the reference number in brackets [1].

So.....please replace....Dobermann & White, 1998....with [1].

Please respect this indication later on.

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63. MATERIALS AND METHODS

64. A field experiment was conducted during *kharif* and *rabi* seasons of 2020-21 and 2021-
65. 22 at Agronomy Main Research Farm, Department of Agronomy, Odisha University of
66. Agriculture and Technology, Bhubaneswar, Odisha, India. The climate of the area is warm
67. and moist characterised by hot and humid summer and mild winter, and falls in the
68. moist and hot category group. The soil of experimental plot was loamy sand in
69. texture, acidic, medium in organic carbon, available phosphorus and potassium
70. but low in available nitrogen. The experiment was laid out in a split-plot design with
71. six main plot treatments i.e. Soil test based nitrogen (STBN) (100 kg N/ha), 75% N through soil
72. test based nitrogen(STBN)+ 25% N through FYM, 75% N through STBN + 25% N
73. through vermicompost, N @ 20kg at basal and at LCC < 3, N @ 20kg at basal and at
74. SPAD < 35 and no nitrogen to rice (var. MTU-1061) during *kharif* and three sub plot
75. treatments i.e. lime @ 0.2 LR (0.48 t/ha), gypsum @ 250 kg/ha and lime @ 0.2 LR +
76. gypsum @ 250 kg/ha to groundnut (var. ICGV-91114) during *rabi* each in three
77. replications. The groundnut variety ICGV-91114 was grown as test variety after rice
78. (variety-MTU-1061) harvest during both the experimental years. Recommended doses
79. of P₂O₅ and K₂O @ 40 kg/ha each to rice and N- P₂O₅- K₂O @ 20-40-40 kg/ha were
80. applied to groundnut. Lime requirement was estimated by Woodruff buffer method and
81. applied @ 0.2 LR i.e. 0.48 t/ha to groundnut in the respective treatments. Biometric
82. observations on various growth parameters like height, leaf area index and dry matter
83. accumulation of groundnut were recorded at 30, 60, 90 DAS and at harvest on randomly
84. selected and 10 tagged plants from each plot. Root nodules of groundnut were carefully
85. separated, cleaned, counted, oven dried and weighed at 30, 60 and 90 DAS.
86. Observations on yield attributes like number of pods/plant, kernels/pod, pod weight and
87. kernel weight were taken after separating the main product, cleaning, drying, counting
88. and weighing at harvest. The shelling out turn was worked out by dividing kernel
89. weight by pod weight and multiplying by 100. Yield observations like pod and haulm
90. yield were recorded after separation, drying and weighing after harvest. Harvest index
91. was calculated as ratio of pod yield to pod yield and haulm yield and expressed as
92. percentage. The oil content in kernel was estimated by Soxhlet's apparatus using
93. petroleum ether as extractant (Sankaran, 1965) and oil yield was obtained by
94. multiplying oil content with pod yield and the shelling out turn taking 8% moisture in
95. pods into account.
96. Oil yield (kg/ha) =

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For example:
2.1. Experimental site
.....
2.2. Biological material
.....
2.3. Experimentally variants
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And so on....
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At the end:
2....? Statistical analysis
.....

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Please explain each abbreviation at its first apparition in text (as I reviewed in Abstract), even if it can appear as a known name.

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Comment [E10]: Biometric observations ?
or
Biometric determinations

Comment [E11]:groundnut have been carried out at.....,90 days after sowing (DAS) and....

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Comment [E13]: quantification

$$\frac{\text{Oil content (\%)}}{100} \times \frac{\text{Shelling out turn (\%)}}{100} \times \text{Pod yield (kg/ha)} \times \frac{\text{Moisture (\%)}}{100}$$

97. Protein content in kernels of groundnut was computed by multiplying percent seed
 98. nitrogen with a factor of 6.25 (AOAC, 1960). The protein yield/ha was calculated by
 99. multiplying protein content with corresponding seed yield taking into account 8%
 100. moisture content in pods. Observations on the above characters in groundnut were
 101. recorded and data were analyzed statistically as per procedure prescribed by Gomez
 102. and Gomez (1984).

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 The obtained results of the above characteristics....

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103. RESULTS AND DISCUSSION

104. Growth parameters of groundnut

105. Application of site-specific nitrogen management practices to preceding rice and
 106. various sources of calcium and sulphur to groundnut significantly affected different
 107. growth parameters as presented in Table 1. The plant height increased progressively
 108. with advancement in crop growth age up to harvest. With respect to site specific
 109. nitrogen management practices applied to preceding rice, application of 75 % N
 through
 110. STBN + 25 % N through vermicompost resulted in significantly highest plant height
 at
 111. harvest (38.68 cm), number of root nodules per plant (97.4), nodule weight per plant
 112. (112.9 mg/plant) at 90 DAS and dry matter accumulation at harvest (643.0 g/m²)
 113. followed by the treatment 75 % N through STBN + 25 % N through FYM and STBN.
 114. Lowest values were obtained by no nitrogen treatment to preceding rice. Application
 115. of 75 % N through STBN + 25 % N through vermicompost to rice recorded the
 highest
 116. leaf area index (LAI) (3.67) at 90 DAS which was at par with 75 % N through STBN
 117. + 25 % N through FYM (3.62). The maximum increase in growth characters in
 118. groundnut due to the residual effect of above site specific nitrogen management
 119. treatments might be due to combined effect of organic and inorganic fertilizers that
 120. increased nutrient availability and microbial activity, resulting in better nutrient
 121. absorption and crop growth. The results are similar to the findings of
 Channaveerswami
 122. (2005), Singhet *et al.* (2011), Javed S and Panwar A. (2013) and Bekele *et al.* (2019).
 123. Similarly, pooled data showed significantly taller plant height (36.13 cm), maximum
 124. number of root nodules per plant (82.0) and nodule weight per plant (95.8 mg/plant)
 at
 125. 90 DAS and dry matter accumulation at harvest (596.2 g/m²) by application of lime @
 126. 0.2 LR + gypsum @ 250 kg/ha followed by the treatment lime @ 0.2 LR. Again,
 127. application of lime @ 0.2 LR + gypsum @ 250 kg/ha to groundnut produced the
 highest
 128. LAI (3.42) at 90 DAS which was at par with application of lime @ 0.2 LR (3.38). The

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129.increase in growth attribute when lime was added to groundnut may be because liming

130.increases the pH levels in soil thus increasing alkalinity which provides a source of

131.calcium and magnesium essential for plant growth. As for the increase in growth

132.attribute when sulphur was applied may be because sulphur is essential for nitrogen-

133.fixing nodules on legumes and in the formation of chlorophyll. Similar findings were

134.also reported by several workers *i.e.* Mandal and Mandal (1998),Noman *et al.* (2015),

135.Das *et al.* (2016) and Aier and Nongmaithem (2020)

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Table 1. Growth parameters of groundnut as influenced by various site specific nitrogen management practices in rice and sources of lime and sulphur in groundnut (pooled over 2020-21 and 2021-22)

UNDER PEER REVIEW

Treatment	Maximum plant height (cm) at harvest	Maximum number of root nodules/plant at 90 DAS*	Maximum nodule weight/plant at 90 DAS	Maximum dry matter accumulation (g/m ²) at harvest	Maximum Leaf area index (LAI) at 90 DAS
Site specific nitrogen management in rice					
STBN (100kg N /ha)	36.53	82.1	94.9	593.7	3.44
75 % STBN + 25 % N through FYM	37.65	94.6	109.6	626.1	3.62
75 % STBN + 25 % N through vermicompost	38.68	97.4	112.9	643.0	3.67
N @ 20kg at basal and at LCC < 3	34.40	71.6	80.0	554.6	3.35
N @ 20kg at basal and at SPAD < 35	35.17	75.3	86.4	576.1	3.40
No Nitrogen	30.32	56.2	64.5	420.7	2.85
S.E(m)±	0.134	0.27	0.38	1.95	0.031
C.D. (0.05)	0.40	0.8	1.1	5.75	0.09
Sources of calcium and sulphur in groundnut					
Lime @ 0.2 LR	35.50	78.3	90.7	559.4	3.38
Gypsum@ 250 kg/ha	34.74	75.3	87.7	551.5	3.36
Lime @ 0.2 LR+ Gypsum@ 250 kg/ha	36.13	82.0	95.8	596.2	3.42
S.E(m)±	0.093	0.18	0.21	1.15	0.014
C.D. (0.05)	0.26	0.5	0.6	3.27	0.04
* DAS : Days after sowing					

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Ex.maximum..... 90 DAS (mg/plant)

136. Yield and yield attributes of groundnut

137. Yield attributes

138. Among different site specific nitrogen management practices applied to preceding rice,

139. application of 75 % N through STBN + 25 % N through vermicompost to rice

140. significantly produced the highest number of pods per plant (17.86), 100 pod weight

141. (67.2 g), 100 kernel weight (47.4 g) and shelling out turn (70.6 %) followed by the

142. treatment receiving 75 % N through STBN + 25 % N through FYM and STBN as per

143. pooled data. Again, application of 75 % N through STBN + 25 % N through

144. vermicompost to rice significantly produced the highest number of kernels per pod

145. (1.87) which was found to be at par with the treatment receiving 75 % N through STBN

146. + 25 % N through FYM. Lowest values were obtained in no nitrogen treatment to rice.

147. The increased yield attributes in the inorganic with vermicompost and FYM based

148. treatments might be due to combined effect of organic and inorganic fertilizers that

149. improved soil physical conditions to conserve moisture, increased nutrient availability

150. and microbial activity, resulting in better nutrient absorption, crop growth and pod

151.formation. These are in corroboration to the findings of Singh *et al.* (2011), Sengupta
152.*et al.* (2016) and Bekele *et al.* (2019).

153.Similarly, pooled data revealed that application of lime @ 0.2 LR+ gypsum@ 250
kg/ha

154.to groundnut resulted in highest number of pods per plant (16.86), 100 pod weight
(66.4

155.g), 100 kernel weight (45.9 g) and number of kernels per pod (1.78) followed by

156.application of lime @ 0.2 LR and gypsum@ 250 kg/ha when applied alone. However,

157.application of various sources of calcium and sulphur to groundnut was found to have

158.no significant effect among the treatments for shelling out turn in groundnut as per

159.pooled data (Table 2). Application of lime with gypsum resulted in higher yield

160.attributes in groundnut as there is a specific requirement of both Ca and S for normal

161.growth of groundnut as stated by Harris (1968) and Tandon (1991). The increase in

162.yield attributes on application of sulphur may be because of the favourable effect of

163.sulphur on the growth of groundnut (Aier and Nongmaithem, 2020). The findings are

164.in corroboration with that of Dosani *et al.* (2003), Dutta *et al.* (2004), Mandal *et al.*

165.(2005) and Das *et al.* (2016).

166. **Yield**

167.Pooled data suggested that application of 75 % N through STBN + 25 % N through

168.vermicompost to rice significantly produced the highest pod yield, haulm yield and

169.harvest index (2596 kg/ha, 4554 kg/ha and 36.30 %) followed by the treatment

170.receiving 75 % N through STBN + 25 % N through FYM (2460 kg/ha, 4506 kg/ha
and

171.35.65 %) and STBN (2270 kg/ha, 4338 kg/ha and 34.32 %). Lowest values were

172.obtained by no nitrogen treatment. Similarly, among the various sources of calcium
and

173.sulphur, application of lime @ 0.2 LR+ gypsum@ 250 kg/ha to groundnut resulted in

174.highest pod yield, haulm yield and harvest index (2291 kg/ha, 4343 kg/ha and 34.38
%)

175.followed by application of lime @ 0.2 LR and gypsum @ 250 kg/ha (Table 2).

176.Due to improvement in growth attributes such as dry matter production, LAI, CGR,

177.nodule count and weight etc. owing to application of lime and gypsum along with

178.residual effect of available nutrients from vermicompost or FYM, there was better

179.translocation of photosynthates to sink leading to higher yield of groundnut.

180.Improvement in vegetative structures for nutrient absorption and photosynthesis,
strong

181.sink strength through development of reproductive structures and production of

182.assimilates under influence of applied sulphur through gypsum maintained balance

183.source-sink might have resulted in increased yield attributes and thus yield. Similarly,

184.calcium through lime plays an important role in the reproductive development of

185.groundnut. This is probably because in the absence of both xylem and phloem supply

186.of Ca, the penetrating gynophores modify themselves into absorbing organs of Ca
from

187.the immediate fruiting zone (Singh, 2007). Several workers observed increase in

188. groundnut yield due to application of both lime and gypsum like Mandal *et al.* (2005),
189. Shamshuddin *et al.* (2009), Ghosh *et al.* (2015), Aier and Nongmaithem (2020).
190. Similarly, among lime and gypsum, lime was more efficient than gypsum in
increasing
191. exch. Ca in the 0-150 mm soil layer, possibly because of the higher Ca concentration
192. in the lime than in the gypsum and because of the leaching of Ca when applied as
193. gypsum to this soil (Blamey and Chapman, 1982).

Table 2. Yield and yield attributes of groundnut as influenced by various site specific nitrogen management practices in rice and sources of lime and sulphur in groundnut (pooled over 2020-21 and 2021-22)

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2270.....2,270
4338.....4,338
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UNDER PEER REVIEW

Treatment	Number of pods at harvest	Number of kernels/pod	100 – pod weight (g)	100- kernel weight (g)	Shelling out turn (%)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)
Site specific nitrogen management in rice								
STBN (100kg N/ha)	16.93	1.78	66.5	45.9	69.1	2270	4338	34.32
75 % STBN + 25 % N through FYM	17.49	1.84	66.8	46.8	70	2460	4506	35.65
75 % STBN + 25 % N through vermicompost	17.86	1.87	67.2	47.4	70.6	2596	4554	36.3
N @ 20kg at basal and at LCC < 3	16.24	1.72	65.3	44.9	68.9	2047	4128	33.1
N @ 20kg at basal and at SPAD < 35	16.54	1.74	65.9	45.4	68.9	2171	4242	33.83
No Nitrogen	12.33	1.52	63.5	42	66.2	1432	3256	30.53
S.E(m)±	0.139	0.014	0.11	0.1	0.18	15.5	12.7	0.153
C.D. (0.05)	0.41	0.04	0.3	0.3	0.5	46	37	0.45
Sources of calcium and sulphur in groundnut								
Lime @ 0.2 LR	16.01	1.74	65.8	45.4	68.8	2118	4108	33.82
Gypsum@ 250 kg/ha	15.83	1.7	65.3	45	68.9	2078	4061	33.66
Lime @ 0.2 LR+ Gypsum@ 250 kg/ha	16.86	1.78	66.4	45.9	69.1	2291	4343	34.38
S.E(m)±	0.047	0.008	0.05	0.06	0.1	5.8	11.5	0.1
C.D. (0.05)	0.13	0.023	0.1	0.2	NS	16	33	0.27

194. Interaction effect

195. The interaction effect was found to be significant among the treatments as regards to pod yield (Table 3). Application of 75 % N through STBN + 25 % N through vermicompost

197. in rice with lime @ 0.2 LR+ gypsum@ 250 kg/ha application in groundnut resulted in 198. the highest pod yield (2740 kg/ha), followed by the application of 75 % N through STBN

199.+ 25 % N through FYM in rice with lime @ 0.2 LR + gypsum@ 250 kg/ha application

200.in groundnut (2592 kg/ha). The interaction effect may be due to maintained higher pH

201.in the soil by neutralizing the acidity and by buffering action of applied organic manure

202.and liming and increased organic status of soils that improved physical conditions of

203.soils and microbial activity resulting in higher growth, yield attributes and yield. This

204.is similar to as reported by Pattanyak *et al.* (2011) and Singh *et al.* (2011).

Table 3. Interaction effects of site specific nitrogen management practices and sources of calcium and sulphur on pod yield of groundnut (pooled over 2020-21 and 2021-22)

Site specific nitrogen management in rice (N)	Sources of calcium and sulphur in groundnut (L)		
	Lime @ 0.2 LR	Gypsum@ 250 kg/ha	Lime @ 0.2 LR+ Gypsum@ 250 kg/ha
	Pod yield (kg/ha)		
STBN (100kg N /ha)	2229	2196	2385
75 % STBN + 25 % N through FYM	2413	2374	2592
75 % STBN + 25 % N through Vermicompost	2549	2500	2740
N @ 20kg at basal and at LCC < 3	2011	1953	2176
N @ 20kg at basal and at SPAD < 35	2128	2092	2293
No Nitrogen	1380	1354	1562
	SEm(±)		CD (0.05)
N	15.45		45.58
L	5.77		16.39
N x L	19.28		56.14
L x N	14.12		40.15

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205. Oil content and oil yield of groundnut

206.As per pooled analysis, application of 75 % N through STBN + 25 % N through

207.vermicompost to rice resulted in highest oil content (48.19 %) which was found to be

208.at par with treatment receiving 75 % N through STBN + 25 % N through FYM (48.03

209.%). Further, application of 75 % N through STBN + 25 % N through vermicompost to

210.rice resulted in highest oil yield (798.7 kg/ha) followed by the application of 75 % N

211.through STBN + 25 % N through FYM (749.2 kg/ha) (Table 4).Improvement in oil

212.content of groundnut under combined and balanced application of mineral

213.fertilizers and vermicompost might be associated with improved availability and uptake

214.efficiency of nutrients like: P, potassium (K), iron (Fe) and zinc (Zn) due to vermicompost (Naveen and Mevada,

215.2012; Choudhary *et al.*, 2015). Similarly, application of lime @ 0.2 LR+ gypsum@ 250

216.kg/ha to groundnut resulted in highest oil content and oil yield (47.79 % and 682.2 217.kg/ha respectively) followed by the application of gypsum @ 250 kg/ha (47.55 % and 218.660.5 kg/ha respectively) (Table 4).Lime and gypsum increased the oil content and 219.yield because enough calcium content in soil around the peanut pods leads to increased

220.yield, oil content and protein content of the kernel. Improvement in oil content with 221.sulphur application might be due to involvement of sulphur directly in oil synthesis. 222.These are similar as reported by Rao *et al.* (2013) and Bekele *et al.* (2019).

223. **Protein content and protein yield of groundnut**

224.Perusal of pooled data on protein content and protein yield of groundnut (Table 4)

225.revealed that application of 75 % N through STBN + 25 % N through vermicompost to

226.rice resulted in highest protein content (20.36 %) which was found to be at par with all

227.the treatments except no nitrogen treatment. Further, application of 75 % N through 228.STBN + 25 % N through vermicompost to rice resulted in highest protein yield (486.1 229.kg/ha) followed by the application of 75 % N through STBN + 25 % N through FYM 230.(458.5 kg/ha). The better supply of nitrogen through STBN + vermicompost might have

231.helped in better absorption and utilization of all plant nutrients and a large proportion 232.of photosynthates may have diverted to protein formation (Sharma *et al.*, 2014). There 233.was no significant difference among the treatments due to application of sources of 234.calcium and sulphur to groundnut with regards to protein content is concerned but 235.application of lime @ 0.2 LR+ gypsum@ 250 kg/ha to groundnut resulted in highest 236.protein yield (424.6 kg/ha) followed by application of lime @ 0.2 LR (388.6 kg/ha).

237.The increase in oil yield and protein yield with the application of organic manures is 238.consequence of the increase in oil content and protein content and grain yield (Saxena 239.*et al.*, 2001). Higher oil yield and oil content with increased application of sulphur also

240.attributed to protein and enzyme synthesis as it is a constituent of sulphur containing 241.amino acids namely methionine, cysteine and cystine. Similar results have been reported

242.by Basu *et al.* (2008), Rao *et al.* (2013) and Chaudhary *et al.* (2015).

Table 4. Oil content, oil yield, protein content and protein yield of groundnut as influenced by various site specific nitrogen management practices in rice and sources of lime and sulphur in groundnut (pooled over 2020-21 and 2021-22)

Treatment	Oil content (%)	Oil yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)
Site specific nitrogen management in rice				
STBN (100kg N /ha)	47.71	684.2	20.11	420
75 % STBN + 25 % N through FYM	48.03	749.2	20.28	458.5
75 % STBN + 25 % N through vermicompost	48.19	798.7	20.36	486.1
N @ 20kg at basal and at LCC < 3	47.43	651	19.98	375.8
N @ 20kg at basal and at SPAD < 35	47.67	648.5	20.07	400.2
No Nitrogen	46.39	452.3	18.61	245.3
S.E(m)±	0.094	14.68	0.24	6.55
C.D. (0.05)	0.28	43.3	0.71	19.3
Sources of calcium and sulphur in groundnut				
Lime @ 0.2 LR	47.37	649.2	19.87	388.6
Gypsum@ 250 kg/ha	47.55	660.5	19.74	379.7
Lime @ 0.2 LR+ Gypsum@ 250 kg/ha	47.79	682.2	20.08	424.6
S.E(m)±	0.06	6.79	0.122	2.62
C.D. (0.05)	0.17	19.3	NS	7.4

243. CONCLUSION

244. From the above study, it may be concluded that, a combination of inorganic and organic

245. source of nitrogen particularly 75% STBN + 25% N either through vermicompost or

246. FYM to rice along with lime + gypsum to succeeding groundnut can be recommended

247. to farmers of Odisha, [India](#) for enhancing the growth, yield and quality parameters of

248. groundnut.

249. References

250. Aier, I. and Nongmaithem, D. 2020. Response of Groundnut (*Arachis hypogaea* L.) to

251. Lime and Different Levels of Sulphur. *International Journal of Bio-resource and Stress*

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1. Hilly M, Adams ML, Nelson SC. A study of digit fusion in the mouse embryo. *Clin Exp Allergy*. 2002;32(4):489-98.

In your work

1. Dobermann A, White PF. Strategies for nutrient management in irrigated and rainfed lowland rice systems. *Nutr. Cycl. Agroecosyst.* 1998; 53:1-18.

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252. *Management*. **11**(6):585-589.

253. AOAC. 1960. Official and Tentative Methods of Analysis, 9th Ed., Association of

254. Official Agricultural Chemists, Washington.

255. Basu, M., Bhadoria, P.B.S. and Mahapatra, S.C. 2008. Growth, nitrogen fixation, yield

256. and kernel quality of peanut in response to lime, organic and inorganic fertilizer levels.

257. *Bioresource Technology*. **99**: 4675-4683.

258. Bekele, G., Dechassa, N., Tana, T. and Sharma, J.J. 2019. Effects of nitrogen,

259. phosphorus and vermicompost on groundnut yield in Babile District, eastern Ethiopia.

260. *Oil Crop Science*. **4**(2): 75-89.

261. Blamey, F.P.C. and Chapman, J. 1982. Soil amelioration effects on peanut growth,

262. yield and quality. *Plant and Soil*. **65**: 319-334.

263. Channaveerswami, A.S. 2005. Studies on integrated nutrient management and planting

264. methods on seed yield and quality of groundnut. *Ph.D. Thesis*, University of

265. Agricultural Sciences, Dharwad, Karnataka.

266. Chaudhary, J.H., Sutaliya, R. and Desai, L.J. 2015. Growth, yield, yield attributes and

267. economics of summer groundnut (*Arachis hypogaea* L.) as influenced by integrated

268. nutrient management. *J Appl & Nat Sci*. **7**(1): 369-72.

269. Das, S., Das, A., Idapuganti, R.G., Layek, J. and Chowdhury, S. 2016. Growth and

270. physiology of groundnut as influenced by micronutrients and liming in acid soil of north

271. east India. *Indian Journal of Hill Farming*. **29**(20):40-47.

272. Dobermann, A. & White, P.F. 1998. Strategies for nutrient management in irrigated

273. and rainfed lowland rice systems. *Nutr. Cycl. Agroecosyst*. **53**: 1-18.

274. Dosani, A.A.K., Chatterjee, A., Talashilkar, S.C., Dhopavkar, R.V. and Meheta, V.B.

275. 2003. Changes in soil acidity as influenced by lime application in groundnut in alfisols

276. of Konkan. *Ind. J. Agric. Sci*. **73**:618-19.

277. Dutta, R., Gogoi, P.K., Sarma, B.N., Barman, P. and Decka, N.C. 2004. Effect of levels

278. of lime and phosphorus on production of groundnut (*Arachis hypogaea* L.). *Leg. Res*.

279. **27**(4): 274-277.

280. Geethalakshmi, V. and Loudurgraj, A.A. 1998. Effect of gypsum application on yield
281. and economics of groundnut (*Arachis hypogaea* L.). *Legume Research*. **21**(1): 13-16.
282. Ghosh, A., Singh, V.J., Srihima, G., Sahoo, P. and Chakraborti, S.K. 2015. Effect of
283. gypsum and lime on seed yield parameters of groundnut (*Arachis hypogaea*). *Journal*
284. *Crop and Weed*. **11**:5-9.
285. Gomez, K.A and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. A
286. *Wiley Inter Science Publication*, 76-83.
287. Harris, H.C. 1968. Calcium and boron effects on Florida peanuts. Tech. Bull. 723,
288. Florida Agriculture Experiment Station, 18.
289. Javed, S. and Panwar, A. 2013. Effect of biofertilizer, vermicompost and chemical
290. fertilizer on different biochemical parameters of *Glycine max* and *Vigna mungo*.
Recent
291. *Res Sci Technol*. **5**: 40-44.
292. Kumar, M., Khan, M.H., Singh, P., Ngachan, S.V., Rajkhowa, D.J., Kumar, A., Devi,
293. M.H., 2012. Variable lime requirement based on differences in organic matter content
294. of iso-acidic soils. *Indian Journal of Hill Farming*. **25**(1), 26–30.
295. Mandal, P.S. and Mandal, L.N. 1998. Effect of molybdenum, phosphorus and lime
296. application to acid soils on dry matter yield and molybdenum nutrition of lentil.
Journal
297. *of Plant Nutrition*. **21**:139-147.
298. Mandal, S., Samui, R.C. and Mondal, A. 2005. Growth, yield and yield attributes of
299. groundnut cultivars as influenced by gypsum application. *Legume Res*. **28**: 119-21.
300. Naveen, K.H. and Mevada, K.D. 2012. Performance of different composts and
301. biofertilizer on yield and quality of green gram (*Vigna radiata* L.). *Adv Res J Crop*
302. *Improv*. **3**(1): 17-20.
303. Noman, H.M., Rana, D.S. and Rana, K.S. 2015. Influence of sulphur and zinc levels
304. and zinc solubilizer on productivity, economics and nutrient uptake in groundnut
305. (*Arachis hypogaea* L.), *Indian Journal of Agronomy*, **60**(2): 301–306.
306. Pattanayak, S.K., Mishra, U.K., Sarkar, A.K. and Majumdar, K. 2011. Integrated
307. nutrient management for groundnut and red gram on acid soils of Odisha. *Better*
Crops – South Asia. **95**(2): 8-10.

- 308.Rao, K.T., Rao, A.U. and Sekhar, D. 2013. Effect of Sources and Levels of Sulphur on
309.Groundnut. *Journal of Academia and Industrial Research (JAI)*. **2**(5): 268-270.
- 310.Sankaran, A. 1965. *A Laboratory Manual for Agricultural Chemistry*. Asia Pub.,
311.Bombay: 258.
- 312.Saxena, H.S., Mandal, M.M.A. and Chandel, A.S. 2001. Effect of inorganic and organic
313.sources of nutrients on soybean (*Glycine max* L.). *Indian Journal of Agronomy*.**44**:135-140.
- 314.Sengupta, A.S., Gunri, K. and Basu, T.K. 2016. Performance of short duration
315.groundnut (*Arachis hypogaea* L.) variety (TG 51) as influenced by nutrient
316.management strategy under new alluvial zone of West Bengal. *Legume Res.* **39**(1):
91-95.
- 317.Shamshuddin, J. and Ismail, H. 1995. Reactions of ground magnesium limestone and
318.gypsum in soil soils with variable-charge minerals. *Soil Sci. Am. J.* **59**: 106-112.
- 319.Shamshuddin, J., Fauziah, I.C. and Bell, L.C. 2009. Effect of Dolomitic Limestone and
320.Gypsum Applications on Soil Solution Properties and Yield of Corn and Groundnut
321.Grown on Ultisols.*Malaysian Journal of Soil Science.* **13**: 1-12.
- 322.Sharma, S., Jat, N.L., Puniya, M.M., Shivran, A.C. and Choudhary, S. 2014. Fertility
323.level and biofertilizer on nutrient concentration, uptake and quality of groundnut.
324.*Annals of Agricultural New Series*.**35**:71-74.
- 325.Singh, B.K., Pathak, K.A., Verma, A.K., Verma, V.K. and Deka, B.C. 2011. Effects of
326.vermicompost, fertilizer and mulch on Plant growth, nodulation and pod yield of
French bean (*Phaseolus vulgaris* L.). *Veg Crop Res Buln.* **74**: 153-165.
- 327.Singh, LA. 1999. Mineral Nutrition of Groundnut. *Scientific Publishers, India.* **2**:
328.161–200.
- 329.Singh, R.A. 2007. Effect of variable doses of potassium, sulphur and calcium on pod
330.yield of short duration summer groundnut (*Arachis hypogaea* L.). *Internat. J. agric.*
331.*Sci.***3**(1) : 196-198.
- 332.Tandon, H.L.S. 1991. Sulphur Research and Agricultural production in India (3 Edn).
333.The Sulphur Institute. Washington, D.C. USA, pp.140.

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