Response of Groundnut to Balanced Fertilisation and Omission of Potassium

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On-farm and on-station trials showed that balanced fertilisation (i.e., applying the right rates of N, P, K, S, Zn, B, and Ca) helped in maximising groundnut yield, nutrient uptake, and farmer profitability. Skipping of K application to groundnut for one-season results in a yield loss of 335 kg/ha, in addition to the depletion of about 34 kg/ha of soil K reserves.

Odisha grows oilseed crops covering 0.77 million (M) ha area or 8.7% of the total cultivated area in the state (FAI, 2012). Of the major oilseeds grown in the state, groundnut is the predominant crop covering an area of 0.25 M ha with a production and productivity of 0.42 M t and 1,680 kg/ha, respectively. The state requires an additional oilseed production of 1.4 M t to meet the demand of the projected population increase (45 M by 2020) (Orissa Agriculture Statistics, 2009-10).

The majority of the soils on which groundnut is grown in the state are light-textured, red and acidic soils. These soils are devoid of organic C and exhibit deficiencies of not only NPK, but also of secondary and micronutrients such as S, Zn and B. Groundnut crop with an economic yield of 2.0 to 2.5 t/ha requires about 160 to 180 kg N, 20 to 25 kg P, 80 to 100 kg K, 60 to 80 kg Ca, 15 to 20 kg S, 30 to 45 kg Mg, 300 to 400 g Mn, 150 to 200 g Zn, 140 to 180 g B, and 8 to 10 g Mo (Singh, 1999). Similarly, Mishra (2004) reported that groundnut crop with a yield of 1.8 t/ha removed 212 kg N, 30 kg P, 115 kg K, 75 kg Ca and 15 kg S/ha in the Inceptisols of Bhubaneswar. Unfortunately, the intensity of fertiliser use ($N+P_2O_5+K_2O$) in Odisha is very low at 56.5 kg/ha (i.e., 35.5, 14.9 and 6.1 kg/ha N, P_2O_5 and K_2O, respectively). Satyanarayana and Tewatia (2009) reported that total nutrients added through fertilisers in Odisha account for only 58% of the crop nutrient removal, while fertiliser K added accounts for only about 16% of the K removed by crops. This results in severe mining of nutrients from soils and, especially, a net negative K balance in the state. For example, Motsara (2002) reported that almost one-third of Odisha soils are low in available K. Both under and imbalanced application of fertilisers are probably the reason why researchers have not been able to break the stagnant yield barrier in groundnut (Singh, 1999). It is, therefore, important to understand the response of balanced fertilisation (and especially K responses) in different groundnut-growing regions of Odisha.

Table 1. Details of fertiliser treatments used at different experimental sites.

S. No.	Treatment details	Location	BFT* details for different locations, kg/ha
T_1	BFT*	Bhubaneswar (kharif)	$N_{30}P_{40}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1300}$****
T_2	N omission (T_1 – N)	Jajpur Deoda (kharif)	$N_{30}P_{40}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1300}$
T_3	P omission (T_1 – P)	Bhubaneswar (rabi)	$N_{30}P_{50}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{500}$
T_4	K omission (T_1 – K)	Sankaradiha (rabi)	$N_{30}P_{50}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1120}$
T_5	S omission (T_1 – S)	Sankaradiha (rabi)	$N_{30}P_{40}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1200}$
T_6	B omission (T_1 – B)	Bhuban (rabi)	$N_{30}P_{50}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1000}$
T_7	Zn omission (T_1 – Zn)	Bhuban (rabi)	$N_{30}P_{60}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1540}$
T_8	Ca omission (T_1 – Ca)	Sankaradiha (rabi)	$N_{30}P_{60}K_{60}S_{56}B_{1.5}$Zn3.3$Ca_{1680}$
T_9	RDF** ($N_{20}P_{40}K_{40}S_{45}B_{1.0}Zn_{2.5}Ca_{500}$)	Sankaradiha (rabi)	$N_{30}P_{50}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1000}$
T_{10}	FFP*** ($N_{22.5}P_{72.5}K_{57}$)	Bhuban (rabi)	$N_{30}P_{50}K_{60}S_{56}B_{1.5}Zn_{3.3}Ca_{1000}$

*BFT denotes balanced fertiliser treatment, which varied for each location; **RDF = state-recommended fertiliser rate, which remained constant for all experimental sites; ***FFP = farmers' fertiliser practice, which again remained constant for all experimental sites; ****Calcium (Ca) applied through Paper Mill Sludge (PMS) as the liming material.

Experiments were conducted at the Central Research Station of Orissa University of Agriculture and Technology (OUAT), Bhubaneswar and in the farmers' fields in Dharmasala block of district Jajpur. The replicated station trial was conducted during both kharif and rabi seasons of 2011-12, while one, non-replicated on-farm trial was conducted in village Achutapur during kharif 2011 and seven, non-replicated on-farm trials were conducted in Sankaradiha and Bhuban villages during rabi 2011-12. All experimental soils were analysed for physical and chemical properties before conducting the experiments. All soils were acidic (pH range 4.7 to 6.2) with low OC (range 3.1 to 6.5 g/kg), low N (140 to 180 kg/ha), low to high P (6.7 to 66.8 kg/ha), low to medium K (71 to 208 kg/ha), low S (6 to 10.5 kg/ha), B (0.28 to 0.35 kg/ha), and Zn (0.15 to 0.48 kg/ha). Lime requirement for the different experimental sites varied from 0.48 in Bhubaneshwar to 1.9 t/ha in Bhuban. The experimental treatments were formulated based on the results of this initial soil analysis (**Table 1**). A total of 10 treatments (i.e., one balanced fertilisation treatment (BFT), omission of N, P, K, S, Zn, B and Ca from BFT, one state recommended dose of fertiliser (RDF) and one farmers' fertiliser practice (FFP)) were used at each location. BFT varied across different locations, while RDF and FFP treatments were the same at all the experimental sites. During kharif 2011, groundnut variety Smruti (OG 52-1) was sown during July 16 to 25 at both the locations at a spacing of 30 x 10 cm. During the rabi season, sowing in 8 different locations was completed between November 12 to 16 and the variety TMV-2 was sown at a seed rate of 125 kg/ha. All nutrients were applied at sowing, while 50% Zn as Zn-EDTA was applied at sowing and the remaining 50% was topdressed in 2 equal splits at 45 and 60 days after sowing (DAS). The sources of nutrients used were urea,

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulphur; Mg = magnesium; Mn = manganese; Mo = molybdenum; Zn = zinc; B = boron; Ca = calcium; C = carbon; EDTA = ethylenediaminetetraacetic acid.

Table 2. Effect of balanced fertilisation and K omission on yield, quality attributes and economics of groundnut.

Treatments	Pod yield, kg/ha	Haulm yield, kg/ha	Yield difference, kg/ha	Oil content, %	Oil yield, kg/ha	Gross return, ₹/ha	Net return, ₹/ha	Benefit:Cost ratio
Kharif groundnut, Bhubaneswar Site 1 (Replicated trial)								
BFT	1,565	756	-	48.6	761	62,600	26,780	1.75
-K	1,246	574	319 (20.4)	47.7	594	49,840	15,142	1.44
RDF	1,068	750	497 (31.7)	46.8	500	42,720	8,928	1.26
FFP	1,060	780	505 (32.3)	45.0	477	42,400	12,719	1.40
C.D. (p = 0.05)	187	135	-	0.89	113			
Kharif groundnut, Deoda, Dharmasala Site 2 (Non-Replicated trial, n = 1)								
BFT	1,355	534	-	44.6	604	54,200	18,380	1.51
-K	1,254	556	101 (7.5)	41.8	524	50,160	15,462	1.45
RDF	1,058	514	297 (21.9)	43.8	463	42,320	8,528	1.25
FFP	1,040	450	315 (23.2)	38.7	402	41,600	11,397	1.38
Rabi groundnut, Bhubaneswar Site 3 (Replicated trial)								
BFT	1,850	1782	-	47.5	879	74,000	38,180	2.07
-K	1,456	2110	394 (21.3)	44.8	652	58,240	23,542	1.68
RDF	1,530	1614	320 (17.3)	45.3	693	51,200	17,408	1.52
FFP	1,466	1830	384 (20.8)	43.1	632	58,640	28,437	1.94
C.D. (p = 0.05)	185	243	-	-	-			
Rabi groundnut, Sankaradiha and Bhuban, Dharmasala Site 4 (Non-Replicated trial, n = 7)								
BFT	2,800	770	-	45.3	-	112,000	76,180	3.13
-K	2,450	750	350 (12.5)	41.1	-	98,000	63,302	2.82
RDF	2,500	740	300 (10.7)	44.0	-	100,000	66,208	2.96
FFP	1,990	660	810 (28.9)	37.8	-	79,600	49,397	2.64
C.D. (p = 0.05)	280	120	-	1.34				

n = number of farmer fields in each site. Values in parentheses are percent decline in yield relative to the balanced fertilisation treatment.
Prices: groundnut = ₹40/kg, N = ₹12/kg, P = ₹30/kg, K = ₹16.7/kg.

DAP and SSP, MOP, Elemental sulphur (S-80) and SSP, Borax, Zn-EDTA and paper mill sludge (PMS) for N, P, K, S, B, Zn and Ca, respectively. During the rabi season, prior to sowing, one pre-sowing irrigation was given for uniform germination. Intercultural operations (hoeing and weeding) were taken up at 15 and 25 DAS. For this paper, only the BFT and K Omission treatment data is presented and compared with RDF and FFP treatments.

Results

Among the treatments used, the average groundnut pod yield decreased in the following order: BFT (2,226 kg/ha) > K omission (1,891 kg/ha) > RDF (1,885 kg/ha) > FFP (1611 kg/ha) (**Table 2, Figure 1**). The BFT recorded significantly higher pod yield of groundnut than any of the other treatments used across all locations and seasons. The mean pod yield of groundnut was higher in the rabi season than in the kharif season. Omission of K led to significant decreases of 319, 101, 394, and 350 kg/ha at Bhubaneswar (Kharif), Deoda (Kharif), Bhubaneswar (Rabi) and Sankaradiha & Bhuban (Rabi), respectively, as compared to the BFT treatment. The corresponding mean reductions in pod yield in the RDF were 32, 22, 17 and 11% of the BFT, while for FFP, these values ranged between 21 to 32% of the BFT. No significant difference in pod yield between RDF and FFP was evident, except for Rabi groundnut grown in farmer fields, and all yield attributes also followed a similar trend (data not shown). The mean pod yield of groundnut was reduced by 15.4, 20.4, and 26.3% due to K omission, RDF and FFP, respectively, across locations. These results indicate the importance of potash nutrition and

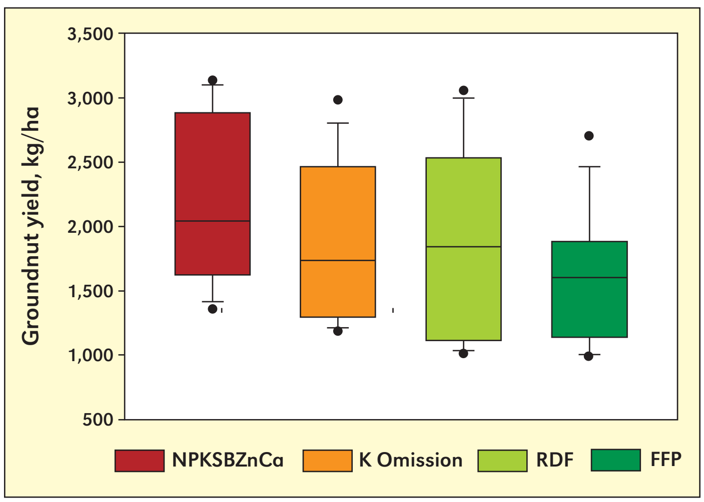

Figure 1. Pod yield of groundnut as influenced by balanced fertilisation and omission of potassium. Boxes represent data within the first and third quartiles (interquartile range). The thin line denotes the second quartile or median. Lines extending beyond the interquartile range denote the 10th to 90th percentile of the data. Statistical outliers are plotted as individual points outside these lines.

Visiting on-station experiment in Bhubaneswar.

Table 3. Total uptake of nutrients (kg/ha) by groundnut as influenced by balanced fertilisation and K omission.

Treatments	N	P	K	S
Kharif groundnut, Bhubaneswar Site 1 (Replicated trial)				
BFT	146.4	7.6	28.3	2.26
-K	137.5	6.2	22.6	1.80
RDF	124.8	6.9	27.4	1.89
FFP	122.0	6.4	26.2	1.97
C.D. (p = 0.05)	5.6	1.6	5.9	0.48
Kharif groundnut, Deoda, Dharmasala Site 2 (Non-Replicated trial, n = 1)				
BFT	139.4	5.8	19.0	1.7
-K	131.0	5.0	15.8	1.2
RDF	130.4	4.4	18.4	1.2
FFP	116.5	4.5	15.4	1.1
Rabi groundnut, Bhubaneswar Site 3 (Replicated trial)				
BFT	144.8	9.7	46.1	8.3
-K	137.7	9.0	31.5	8.3
RDF	135.5	8.3	34.4	8.3
FFP	120.7	9.1	38.6	7.6
C.D. (p = 0.05)	5.6	0.7	3.4	1.0
Rabi groundnut, Sankaradiha and Bhuban, Dharmasala Site 4 (Non-Replicated trial, n = 7)				
BFT	143.6	12.7	49.1	8.7
-K	131.5	9.9	38.1	5.9
RDF	134.6	10.5	41.6	6.5
FFP	114.1	7.0	30.0	5.2
C.D. (p = 0.05)	N.S.	2.0	7.4	1.5

highlight the scope for increasing the production of groundnut through improving the existing nutrient management in RDF and FFP. The authors believe that the nutrient rates in RDF, especially Ca, were not enough to effectively mitigate soil acidity. This is because the Ca applied through PMS in RDF was 500 kg/ha vis-à-vis an average application of 1,164 kg/ha of Ca applied in BFT based on soil testing.

Similar to yields, the BFT recorded higher mean oil content (46.5%) and mean oil yield (748 kg/ha) over the other treatments (**Table 2**). The corresponding values for K omission, RDF and FFP treatments were 44, 45 and 41 % and 590, 552 and 504 kg/ha, respectively. In general, the pod yield, haulm yield, oil content, oil yield and other yield attributing parameters were higher in the rabi season than in the kharif season. This is because the cultivation of groundnut during kharif season is dependent on monsoon rainfall and is often subjected to adverse weather conditions, where there is continuous withdrawal and inadequate supply of nutrients, enhanced leaching and runoff and decreased N_2 fixation in soil.

Economic analysis closely followed the groundnut yield and quality parameters with respect to the treatments used in the study. The BFT gave higher mean gross return of ₹75,700 and a mean net profit of ₹39,880 than all other treatments (**Table 2**). Omission of K from the BFT reduced the net profit by 43, 16, 38 and 17% at Bhubaneswar (kharif), Deoda (kharif), Bhubaneswar (rabi) and Sankaradiha & Bhuban (rabi), respectively. RDF and FFP exhibited the lowest values of economic parameters among all the treatments used.

Total nutrient uptake was significantly influenced by the balanced application of nutrients. The highest total uptake of N (139 to 146 kg/ha), P (6 to 12 kg/ha), K (19 to 49 kg/ha) and S (1.7 to 8.7 kg/ha) were recorded with BFT (**Table 3**). This could have resulted in higher yields with BFT vis-à-vis the other treatments. The highest average yield of 1,893 kg/ha was obtained with removal of 76 kg N, 4.7 kg P, 18.8 kg K, and 2.7 kg S per tonne of groundnut pod yield. A significantly lower total uptake of nutrients under K omission, RDF and FFP as compared to BFT suggests that limitation of one nutrient in the soil affects the uptake of other nutrients. Total N, P, K, and S uptakes in the K omission treatment were 7, 16, 24 and 18% lesser, respectively, than the corresponding total uptakes observed in BFT.

Table 4. Initial soil K status, K addition, K removal and K balance values as influenced by balanced fertilisation and K omission.

Treatments	Initial soil K, kg/ha	K added through fertiliser, kg/ha	Total K removal, kg/ha	K balance, kg/ha	Post harvest soil K, kg/ha
Kharif groundnut, Bhubaneswar Site 1 (Replicated trial)					
BFT	113	60	28.3	145	98.5
-K	113	0	22.6	90.4	69.4
RDF	113	40	27.4	126	74.6
FFP	113	57	26.2	144	70.5
Kharif groundnut, Deoda, Dharmasala Site 2 (Non-Replicated trial, n = 1)					
BFT	147	60	19.0	188	103
-K	147	0	15.8	131	65.3
RDF	147	40	18.4	169	80.2
FFP	147	57	15.4	189	119
Rabi groundnut, Bhubaneswar Site 3 (Replicated trial)					
BFT	127	60	46.1	141	110
-K	127	0	31.5	96	72.3
RDF	127	40	34.4	133	111
FFP	127	57	38.6	145	80.6
Rabi groundnut, Sankaradiha and Bhuban, Dharmasala Site 4 (Non-Replicated trial, n = 7)					
BFT	104	60	49.1	115	159
-K	104	0	38.1	66	128
RDF	104	40	41.6	103	143
FFP	104	57	30.0	131	105

With an average initial soil K status of 123 kg/ha, the average K balances after harvest of groundnut in BFT, K omission, RDF and FFP treatments were 147.2, 95.6, 132.4 and 152.3 kg/ha, respectively (**Table 4**). However, the average post harvest soil K status in BFT, K omission, RDF and FFP treatments were 117.7, 83.8, 102.1 and 93.9 kg/ha, respectively. This indicated a corresponding K mining of 5.3, 39.2, 20.9 and 29.1 kg/ha, respectively.

Summary

Results from our experiments clearly showed that practicing balanced fertilisation significantly improved groundnut yield and economics over the existing state recommendations and farmers' fertiliser practice. Balanced application of nutrients could increase the groundnut yield by almost 30% from the current yield levels in farmer fields with consequent increase in farmer profits. Skipping of K application to groundnut for one-season results in a yield loss of 335 kg/ha, in addition to the depletion of about 34 kg/ha of soil K reserves. Thus, balanced fertilisation offers hope to break the stagnating yield barrier of groundnut in Odisha.

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