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Physical and Economic Optimum of Response Model for NPK Application in Irrigated Groundnut (*Arachis hypogaea* L.)

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Field experiments were conducted to work out the physical and economic optimum of NPK fertilizers required for groundnut by using empirical model. The experiment was conducted in Randomized Block Design (RBD) with different NPK levels *viz*., Control, 25 % Recommended Dose of Fertilizers (RDF) (4:9:14 kg NPK ha^{-1}), 50 % RDF (9:17:27 kg NPK ha^{-1}), 75 % RDF (13:26:41 kg NPK ha^{-1}), 100 % RDF (17:34:54 kg NPK ha^{-1}), 125 % RDF (21:43:68 kg NPK ha^{-1}), 150 % RDF (26:51:81 kg NPK ha^{-1}), 175 % RDF (30:60:95 kg NPK ha^{-1}) and 200 % RDF (34:68:108 kg NPK ha^{-1}). The experiments were conducted during *rabi* 2006-'07 and *kharif* 2007. The results revealed that among the different levels of NPK studied, application of 175 per cent recommended dose of fertilizers (30:60:95 kg NPK ha^{-1}) registered significantly higher growth characters, yield parameters, yield and economic returns. The response model worked for different levels of NPK during *rabi* 2006-07 and *kharif* 2007 seasons indicated that the physical optimum levels for groundnut was 33.9 kg N, 67.5 kg P_2O_5 and 107.3 kg K_2O ha^{-1}, whereas the economic optimum was worked out to be 33.7 kg N, 65.8 kg P_2O_5 and 105.5 kg K_2O ha^{-1}.

Key words: Response model, groundnut, NPK

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Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in India and commonly called as poor man's nut. India ranks first in acreage (6.41 m ha) which accounts for 23.87 per cent of the total world groundnut area and contributes 20.89 per cent (9.36 m t) to the world production (Damodaram and Hegde, 2000). The average productivity of groundnut in India is 1125 kg ha^{-1} which is below the world's average pod yield of 1449 kg ha^{-1}. In Tamil Nadu, groundnut is cultivated in an area of 0.53 m ha with a production of 1.1 m t and the average productivity is 1724 kg ha^{-1}, which is higher than global average (www. agricoop.nic.in).

The removal of major nutrients (NPK) at the present level of crop production has been estimated at 125 kg/ha whereas, the annual addition is hardly 75 kg/ha, resulting in depletion of nutrient reserves of soil (Tandon, 1994). Groundnut removes fairly large quantities of nutrients from the soil and, therefore, it depletes the soil nutrients rapidly unless the soil is adequately manured. Adequate manuring not only improves the yield but also maintains the soil health and sustains the productivity (Lourduraj, 1999). Ghosh *et al.* (2002) stressed that proper fertilizer management for groundnut crop with right kind of nutrients at right time adapting right method of application has significant effect on yield and quality.

N, P and K are essential nutrients and important determinant of plant growth and development.

Addition of N fertilizer generally increases root-shoot ratio and pod yield of groundnut. On the other hand, phosphorus is an important nutrient for all crops in general and legumes in particular. It is a key constituent of ATP and plays significant role in energy transformations in plants and also in various roles in seed formation (Sanker *et al.*, 1984). Phosphorus application increases groundnut yield and yield contributing characters. In addition, K has a beneficial effect on N fixation and transformation of photosynthates from the leaves to the root nodules (Savani *et al.,* 1995). Balanced fertilization of essential plant nutrients, particularly N, P and K in optimum quantity through appropriate method at suitable time in proper proportion always resulted in yield improvement.

Groundnut being a leguminous crop, basal application of little dose of fertilizer nitrogen is recommended by several workers. However, for the above said reasons, the recommended dose of NPK (17:34:54 kg ha^{-1}) needs to be rescheduled. The application of entire nitrogen at the time of sowing was not preferable as compared to split application, since the pattern of maximum uptake was between 48 and 72 days after sowing (Panikar, 1981). At this juncture the present practice of basal application of 100 per cent of the recommended dose of NPK fertilizers in groundnut needs to be reviewed. Hence, the present investigation to work out the physical and economic optimum of NPK fertilizers for irrigated groundnut by employing empirical models was attempted.

Materials and Methods

Field experiments were conducted at the Regional Research Station, Tamil Nadu Agricultural University, Vridhachalam during *rabi* 2006-07 and *kharif* 2007 seasons. The soil of the experiment plot was sandy loam in texture, natural (pH 7.0), low in organic carbon (0.5%), low in available nitrogen (232 kg/ha), low in available phosphorus (13 kg/ha) and low in available potassium (243 kg/ha). The experiment was conducted in Randomised Block Design (RBD) with three replications and different NPK levels *viz*., Control, 25 % RDF (4:9:14 kg NPK ha$_{-1}$), 50 % RDF (9:17:27 kg NPK ha$_{-1}$), 75 % RDF (13:26:41 kg NPK ha$_{-1}$), 100 % RDF (17:34:54 kg NPK ha$_{-1}$), 125 % RDF (21:43:68 kg NPK ha$_{-1}$), 150 % RDF (26:51:81 kg NPK ha$_{-1}$), 175 % RDF (30:60:95 kg NPK ha$_{-1}$) and 200 % RDF (34:68:108 kg NPK ha$_{-1}$). The gross plot size was 5.0 m by 4.0 m, and one seed was planted per station at 10 cm within-row and 30 cm inter-row spacing. Irrigation was done as and when required. Seed treatment of *Trichoderma viride* was given @5 g/kg seed at the time of sowing. Need based plant protection measures were followed. The field was kept weed-free by hand weeding and moisture stress was avoided through irrigation. All recommended cultural practices and pest control operations were carried out as required to grow a good crop. The plants from each plot were labeled and kept separated. Various yield components such as number of pods/ plant, 100 kernel weight, shelling percentage, pod yield and haulm yield were taken at harvest. The statistical analyses of the experimental data were performed as per Gomez and Gomez (1984).

Response model

Quadratic response model

The quadratic model was proposed by Heady and Pesek (1954) to provide a continuous and differential response function that accommodated interactions with other nutrient forms. This model has found widespread use because of its simplicity.

Let '**y**' be the yield in kg ha$_{-1}$

'x' be the applied nutrient

and a linear equation between and $\sqrt{Z}$ x could be estimated

$$\sqrt{Z} = a + bx$$

Where Z = A-y

A = Maximum yield

$$(A\text{-}y)_{1/2} = a+bx$$

$$(A\text{-}y) = (a+bx)_2$$

$$= a_2 + 2abx + b_2\, x_2$$

$$y = A\text{-} (a_2+2abx+b_2x_2)$$

$$y = (A\text{-}a_2) – 2abx – b_2\, x_2$$

$$y = \alpha + \beta\, x + \gamma\, x_2$$

$$\alpha = A – a_2$$

$$\beta = - 2ab$$

$$\gamma = - b_2$$

Results and Discussion

Growth and Yield characters

Groundnut growth in terms of its dry matter production was more pronounced with application of 200 per cent of recommended dose of fertilizers (34:68:105 kg NPK ha$_{-1}$). The least dry matter production was noticed with control. The excess dose of NPK application reported that increased dry matter production significantly with the enhanced rate of NPK supply at various stages of growth up to harvest.. This is in conformity with the finding of Barik *et al.* (1998).

On perusal of data on productivity of groundnut during *rabi* 2006-07 and *kharif* 2007 seasons, it is evident that the results were significantly favourable for application of 175 per cent of recommended dose of fertilizers (RDF) (30:60:95 kg NPK ha$_{-1}$). The number of matured pods per plant, hundred kernel weight and sound matured kernel per cent were also higher under application of 175 per cent of recommended dose of fertilizers (RDF) (30:60:95 kg NPK ha$_{-1}$) (Table 1 and 2). The increase in the yield components by using the higher level of NPK might be due to the abundant nutrients in the soil solution which would have facilitated nutrients absorption through roots. These results are in full agreement with those obtained by El-Far and Ramadan (2000), Laxminarayana (2004) and Hossain *et al.* (2007), have also reported that increasing rate of NPK application, recorded higher yield and yield attributes of groundnut.

Among the different levels of NPK, application of 175 per cent of RDF registered significantly higher pod yield of 2634 and 2577 kg ha$_{-1}$ during *rabi* 2006-'07 and *kharif* 2007 seasons respectively. However it was on par with application of 200 per cent of RDF (2618 and 2566 kg ha$_{-1}$). Saxena *et al.* (2003) reported that pod yield of groundnut could be increased with increasing levels of N and K. Similar results were also reported by Kachot *et al*. (2001). The per cent increase in the pod yield was 13.4 and 12.4 per cent higher than 100 per cent RDF, during *rabi* 2006-07 and *kharif* 2007 seasons, respectively (Table 1 and 2). Moreover, the positive influence of these treatments through immediate supply of nutrients from inorganic sources especially at the early stage of the crop and slow and steady supply of nutrients from NPK as well as soil throughout the crop growth period might have improved adequate biomass production and improvement in yield parameters resulting in higher pod and haulm yield. Application of 175 per cent RDF (30:60:95 kg ha$_{-1}$) significantly increased the pod yield, which was 66.3 and 62.0 per cent increase over control, during *rabi* 2006-07 and *kharif* 2007 respectively.

Table 1. Effect of NPK levels on yield characters, pod yield (kg ha^{-1}) and economics of groundnut variety VRI 2 (*Rabi* 2006- 07)

Treatment	DMP at harvest (kg ha^{-1})	No.of matured pods/ plant	100 kernel weight (g)	Shelling (%)	Pod yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Total variable cost (Rs ha^{-1})	Returns above variable cost (Rs ha^{-1})	BCR
T_1- Control	4271	7.27	36.69	62.36	887	19514	15000	4514	1.30
T_2- 25 % RDF	5431	8.73	38.27	66.35	1315	28930	15393	13537	1.88
T_3- 50 % RDF	6483	9.67	38.93	68.09	1577	34694	15765	18929	2.20
T_4- 75 % RDF	7236	11.53	39.39	71.16	2019	44418	16158	28260	2.75
*T_5- 100 % RDF	8771	15.67	39.90	73.30	2280	50167	16518	33649	3.04
T_6- 125 % RDF	9580	17.00	40.79	73.84	2385	52477	16911	35566	3.10
T_7- 150 % RDF	10018	18.20	41.38	74.83	2510	55227	17283	37944	3.20
T_8- 175 % RDF	10860	18.73	41.78	75.41	2634	57948	17676	40272	3.28
T_9- 200 % RDF	11220	18.13	41.85	75.66	2618	57596	18036	39560	3.19
S.Ed	84	1.02	2.99	1.82	42				
CD(0.05)	178	2.16	NS	3.86	90				

*100 % RDF - 17:34:54 kg NPK ha^{-1}

In respect of groundnut, because of higher dry matter production, higher pod yield was reported by Nalawade and Patil (2000) and Sanjeev Kumar and Shivani (2001). Higher pod yield due to increase in yield parameters like number of matured pods per plant, pegging percentage and hundred kernel weight as reported by Samui and Ambhore (2000) and Sanjeev Kumar and Ngachan (2001).

Table 2. Effect of NPK levels on yield attributes, pod yield (kg ha^{-1}) and economics of groundnut variety VRI 2 (*Kharif* 2007)

Treatment	DMP at harvest (kg ha^{-1})	No.of matured pods/ plant	100 kernel weight (g)	Shelling (%)	Pod yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Total variable cost (Rs ha^{-1})	Returns above variable cost (Rs ha^{-1})	BCR
T_1- Control	4671	6.4	37.8	60.9	980	21560	15000	6560	1.44
T_2- 25 % RDF	5343	8.1	38.6	65.0	1377	30301	15393	14908	1.97
T_3- 50 % RDF	6449	8.7	38.7	67.0	1615	35537	15765	19772	2.25
T_4- 75 % RDF	7010	10.4	39.4	70.4	1986	43699	16158	27541	2.70
*T_5- 100 % RDF	8597	15.1	39.9	72.3	2257	49647	16518	33129	3.01
T_6- 125 % RDF	9369	16.5	40.2	72.8	2364	52015	16911	35104	3.08
T_7- 150 % RDF	9804	18.1	40.5	73.8	2445	53790	17283	36507	3.11
T_8- 175 % RDF	10544	18.5	40.7	74.4	2577	56687	17676	39011	3.21
T_9- 200 % RDF	11012	18.7	40.7	74.4	2566	56452	18036	38416	3.13
S.Ed	79	1.00	2.90	1.80	41				
CD(0.05)	167	2.10	NS	3.80	88				

*100 % RDF - 17:34:54 kg NPK ha^{-1}

However higher rates of fertilizer addition beyond 175 per cent RDF showed a decline in yield and the higher reduction in yield was noticed with 200 per cent of RDF (34:64:108 kg NPK ha^{-1}). Many workers including Obigbesan and Agboola (1978) and Kayode (1985) have reported in earlier studies that these application of higher amount of nutrients could result in the loss of nutrients easily from the soil through leaching (N), emission of gases (N and P) and possibly K fixation which is not lost from the soil but unavailable to the plants. These results were in accordance with the findings of Chitdeshwari *et al.* (2007).

Response model

In both the seasons, the calculated chi-square value was much lesser than chi square table value (15.2 for n-1 of 8) and this indicated that there was no significant difference between the observed value and predicted pod yield at harvest (Table 3). This confirmed the suitability of the model for prediction. The response model worked for different levels of NPK during *rabi* 2006-07 and *kharif* 2007 seasons indicated that the physical optimum level for groundnut was 33.9 kg N, 67.5 kg P_2O_5 and 107.3 kg K_2O ha^{-1}, whereas the economic optimum worked

Table 3. Physical and economic optimum of response model for NPK in groundnut

Response model	*Rabi* 2006-07			*Kharif* 2007			Mean		
	N	P	K	N	P	K	N	P	K
Physical optimum	33.8	67.4	107.0	34.0	67.6	107.5	33.9	67.5	107.3
Economic optimum	33.6	65.9	105.4	33.7	65.8	105.7	33.7	65.8	105.5

out was 33.7 kg N, 65.8 kg P_2O_5 and 105.5 kg K_2O ha^{-1}. Chitdeshwari *et al.* (2007) also observed that application of higher dose of 34:64:108 kg NPK ha^{-1} was found to be an optimum dose for getting maximum pod yield in groundnut.

Economics

The application of 175 per cent of RDF (30:60:95 kg NPK ha^{-1}) as compared to 100 per cent of RDF (17:34:54 kg ha^{-1}) registered the highest returns above variable cost (Rs. 40,272 and 39,011 ha^{-1} and benefit cost ratio (3.28 and 3.21) during *rabi* 2006-'07 and *kharif* 2007 seasons, respectively). This treatment was closely followed by application of 200 per cent RDF which registered the returns above variable cost of (Rs. 39,560 and 38,416 ha^{-1} during *rabi* 2006-07 and *kharif* 2007 seasons respectively) and benefit cost ratio (3.19 and 3.13).

Conclusion

The response model worked for different levels of NPK during *rabi* 2006-07 and *kharif* 2007 seasons indicated that the physical optimum levels for groundnut was 33.9 kg N, 67.5 kg P_2O_5 and 107.3 kg K_2O ha^{-1}, whereas the economic optimum was 33.7 kg N, 65.8 kg P_2O_5 and 105.5 kg K_2O ha^{-1}.

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