Economics Program
Progress Report-34

Fertilizer Responsiveness of Chickpeas in India

An Analytical Review

S. Rajendran, D. Jha and J.G. Ryan

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh 502 324, India

April 1982

PROGRESS REPORTS are informal communications about ongoing research, or thoughts of ICRISAT staff members, which are designed to stimulate thinking and comments of professional colleagues within and outside the Institute. These reports are not to be considered as formal publications bearing the endorsement of the Institute. Progress reports were earlier referred to as Occasional Papers/Discussion Papers.

Fertilizer Responsiveness of Chickpeas in India: An Analytical Review

S. Rajendran, D. Jha and J.G. Ryan

Chickpea is one of the major pulse crops in India, occupying over 7 million hectares. India grows nearly 73% of the world and 80% of the total SAT chickpeas. The four states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Haryana account for almost 82% of national production.

An important consequence of the recent advances in cereal production in the country has been a decline in the relative production of pulses in general, and of chickpea in particular (Ryan and Asokan 1977). The nutritional implications of this shift are causing concern, and serious efforts are now being made to increase pulse productivity. It is in this context that assessment of responsiveness to, and profitability of, fertilizer application assumes considerable significance. This analytical review focusses attention on the latter aspect and examines whether fertilizer application to this crop is profitable under present technology and price regimes.

Methodology

Three major nutrients are examined -- nitrogen, phosphorus, and potassium, and wherever possible, the interaction effects have also been studied. The general methodology followed and the data used are described below.

Data

Data from 1965 were compiled from agronomic experiments published in research journals, annual reports and theses. These were supplemented by data in the National Index of Agricultural field experiments over the period 1950-55. These are contained in the list of references. From these studies we extracted data on responses at different levels of nutrient application. Since the levels were different in the various

† The authors are Agricultural Officer, Indian Overseas Bank, Madras and previously Technical Assistant, ICRISAT; Professor in Agricultural Economics, Indian Agricultural Research Institute, New Delhi; and — Principal Economist, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, respectively. They acknowledge the comments offered on earlier drafts of this paper by the participants in the ICRISAT Pulse Program seminar and T.S. Walker.

studies, we summarized the data by grouping them into different fertilizer application classes. In almost all cases we had only treatment means to work with in the published material. It was not possible to determine the level of crop protection given in the experiments as this was not mentioned in any of the references used in this study. No attempt was made to classify responses by cultivar or other management practices.

The yield at different levels of fertilizers was compared with that of the control plot and, using the critical difference values, those experiments having responses which were significantly different to the control were tabulated as the number of significant trials at each level of fertilizer. The total number of trials in which each fertilizer levels was used as a treatment is also included in the analysis.

To examine the profitability of fertilizers, the net returns per rupee of expenditure on the nutrients for different levels of fertilizers were calculated for each trial. Data from all trials were put together as frequencies (number of trials) in different net return classes for comparison. These data were subsequently reclassified according to major soil types, to determine the influence of this factor. Average prices for the three years (1974-75 to 1976-77) were used to value chickpea grain and the nutrients. These prices were Rs. 3.98 per kg of N, Rs. 4.09 per kg of P_2O_5 and Rs. 1.56 per kg of chickpea. Current ratios of the prices of fertilizers to chickpeas may be about 50% lower than this. Hence the current profitable doses of fertilizer would tend to be higher than those presented in this paper. The various net return measures used were calculated as follows:

The average gross return per ha (G) at a particular level of nutrient application was defined as: $G = Y \times P_y$

Where Y is the additional chickpea yield per ha over the control at that fertilizer level, and P_y is the chickpea price

The net return per ha (N) was calculated as: $N = Y \times P_y - F \times P_f$

Where F is the quantity of fertilizer and P_f is the price

Then the average net return (R) per ha per Rupee of fertilizer cost was calculated as: $R = \frac{Y \times P_y}{F \times P_f} - 1$ or $N/F.P_f$

It is assumed that increased fertilizer does not require a change in other costs such as labor.

We also calculated marginal net returns per rupee of investment in fertilizers. The calculation is essentially similar to that above, only the Y and F variables are measured as increments over the preceding levels of fertilizer used instead of increments over and above the control. This exercise allows us to determine the level up to which one could increase fertilizer use profitably. Figure 1 represents the schematic yield response of chickpea to various levels of nitrogen application.

At low levels of nitrogen application (N_1) the yield responses (DE) over the control yield at zero fertilizer levels may include a number which are not statistically significant (i.e. the CD is less than DE). At higher nutrient levels (N_2 and N_3) the number of significant responses over and above the control may be greater. However, because response curves generally begin to flatten at higher fertilizer levels, these higher doses, even though they generate statistically significant yield responses over the control, may not be economically significant. The level N_1 may be a profitable dose, and maybe N_2 also adds more to profits compared to N_1. However, it may not be profitable to increase the dose from N_2 to N_3 as the extra yield (AB) may not be worth more than the extra cost of applying (N_3 - N_2) fertilizer.

In the subsequent analysis we show the percentage of experiments where statistically significant yield responses over the controls were obtained.[1] In calculating net returns per rupee of nutrient cost for the various levels of fertilizer used in the experiments, non-significant responses were treated as generating a yield response of zero over the control. Hence in such cases net returns are always -1. Where statistically significant responses occurred (positive or negative), the actual yield differences between the treatments were valued to generate net returns per rupee of nutrient. The percentage of experiments generating losses at each fertilizer level is used as a measure of the relative riskiness of fertilizer application. This is compared with the average level of profits per rupee of nutrient over all experiments, including those generating losses.

It might be argued that one should not give much weight to statistical significance of treatment differences, as non-significant trials also yield some response over control. Though this view questions the validity of statistical analysis, we also calculated the net return per rupee of nutrient cost using the actual yield response of all trials including both significant and non-significant ones.

As a general rule, in the subsequent discussion we regard a net return / cost ratio of 2 as a minimum figure to gauge the attractiveness of fertilizer application on chickpea.

---

1. Virtually all of the experiments reviewed used 5% as the critical level for statistical significance.

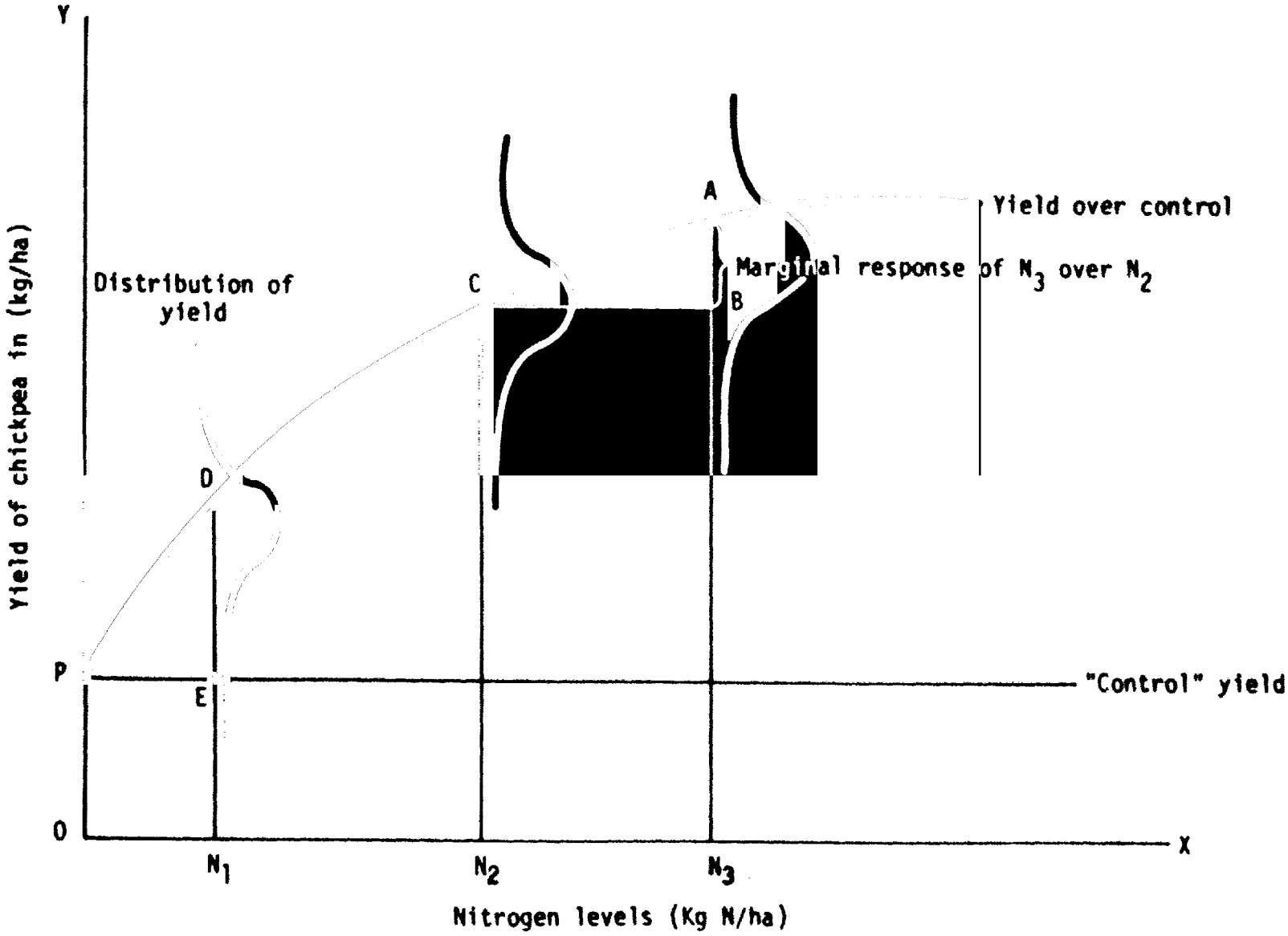

Fig. 1. Schematic fertilizer response.

Results and Discussion

Returns to Nitrogen

In all, 123 experiments were reviewed for the response of chickpea to nitrogen, out of which 76% were under rainfed conditions. In each trial which was analysed the level of nutrients besides N was held constant. However, about half of the N trials had basal doses of P_2O_5 applied, while others had nil. Tables 1 to 6 summarize the results of all rainfed and irrigated trials reviewed. It appears from the tables that the returns to nitrogen are quite profitable under rainfed conditions, and to some extent under irrigated conditions.

1) Rainfed Chickpea:

When yield of non-significant trials was kept the same as the control, average yield response over control increased from 67 kg/ha at a nitrogen level of 5-14 kg/ha to 248 kg/ha at the 30-34 kg/ha level of N. Thereafter average yield declined (Figure 2). The mean response per kg of nitrogen was highest at the 30-34 kg/ha level of N at 7 kg/kg of N. Next highest was the 5-14 kg/ha level of N, where the mean response was 5.8 kg/kg of N. Beyond 34 kg N both the average yield and the mean response falls (Table 1). The trend remains more or less the same after including the actual yield response of non-significant trials (Figure 3). On the other hand the percentage of economic losses tends to increase with increasing levels of nitrogen beyond 5-14 kg/ha and up to 25-29 kg N/ha and then falls to a considerable extent at doses 30-34 kg of N/ha (Table 2).[2] The latter level also generates the greatest net benefit/cost ratio, irrespective of the method of computation. The coefficient of variation of yields was also lowest at the 30-34 kg level of N (Table 1).

From the frequency distribution of net returns per rupee of nitrogen in different experiments, it is evident that the application of low doses of nitrogen is more advantageous than intermediate levels (Table 1). Nearly 43% of the total trials gave an average net return rate exceeding 2.0 at the 5-14 kg N/ha level. For the 20-24 kg N/ha and 30-34 kg N/ha levels, the proportion of such trials were 29% and 44%, respectively. Most previous studies (Bajpai et al., Chowdhury et al., Rathi and Singh, R.S. Singh, and Raju and Samuel) also established the response of chickpea to nitrogen. They advocated a starter dose of nitrogen of 20-30 kg/ha, which not only gives a positive yield response, but also favorably influences the absorption and utilization of phosphorus and other elements. Experiments on cultivator's fields conducted by the All India Coordinated Agronomic

2. Percentage of economic losses refers to the percentage of trials where costs of fertilizers were not exceeded by the extra value of chickpeas.

Table 1. Mean response and frequency distribution of net returns per rupee of nitrogen applied to rainfed chickpea at various levels of nitrogen

	Levels of Nitrogen (Kg N/ha)					
	5-14	15-19	20-24	25-29	30-34	>35
Mean Response[a] (Kg/Kg of N)	5.8	3.3	3.7	3.2	7.0	2.5
Coefficient of variation of response[a] (%)	101	154	138	297	73	68
Net Return/Rs of N[b]:						
Less than 0.00	12	19	25	7	8	3
0.00-0.99	-	2	2	-	3	3
1.00-1.99	4	1	5	-	12	-
2.00-2.99	5	3	9	1	10	-
3.00-4.99	4	4	4	-	5	-
5.00 and above	3	-	-	1	3	-

a On the basis of significant responses only
b Based on a significant responses plus non-significant responses treated as a zero yield response.

Table 2. Average net returns per rupee at various levels of nitrogen

	Levels of Nitrogen (Kg N/ha)					
	5-14	15-19	20-24	25-29	30-34	>35
			RAINFED			
Number of trials	28	29	45	9	41	6
Significant responses	16	10	22	2	34	5
Average net return (Rs/Rs of N) with:						
I) Significant responses only	3.17	2.68	1.85	5.54	2.55	0.20
II) Significant responses plus actual value of non-significant responses	2.17	1.30	1.40	-0.04	2.15	-0.04
III) Significant responses plus non-significant responses treated as zero	1.38	0.26	0.36	0.45	1.94	-0.02
Percentage of economic losses[a]	43	66	56	78	20	50
			IRRIGATED			
Number of trials	6	7	9	6	7	6
Significant trials	3	1	4	3	3	4
Average net return (Rs/Rs of N) with:						
I) Significant trials only	10.83	14.63	0.11	-0.01	-1.85	2.56
II) Significant trials plus actual value of non-significant trials	5.10	0.43	-0.61	-1.51	1.79	-0.37
III) Significant trials plus non-significant response treated as zero	4.92	-0.06	-0.37	-1.74	0.49	-0.34
Percentage of economic losses[a]	50	86	67	83	57	50

a See footnote b, Table 1.

Table 3. Frequency distribution of marginal net return per rupee of nitrogen under rainfed conditions

	20-24 Kg N/ha over 5-14 Kg N/ha	30-34 Kg N/ha over 20-24 Kg N/ha
Less than 0.00	4	2
0.00 - 0.99	-	1
1.00 - 1.99	-	2
2.00 - 2.99	2	2
3.00 - 4.99	5	3
5.00 and above	4	4
Total trials	15	14
Significant trials[a]	12	12

a implies that the increase in yield between the two fertilizer levels was statistically significant.

Table 4. Mean response and frequency distribution of average net returns per rupee of nitrogen applied to rainfed chickpea based on soil classification

	Alluvial	Medium Black	Red & Black	Red & Yellow	Mixed Red & Black and Red & Yellow	Calcareous Sierozem	Tarai
			20-24 Kg N/ha				
Mean response[a] (kg/kg of N)	6.0	2.4	3.0	3.5	9.2	6.4	0.0
Coefficient of variation of response[a] (%)	84	182	172	200	21	173	
Net Return/Rs of N[b]:							
Less than 0.00	2	11	5	3	-	2	2
0.00 - 0.99	2	-	-	-	-	-	-
1.00 - 1.99	1	3	-	-	-	1	-
2.00 - 2.99	3	4	1	-	1	-	-
3.00 - 4.99	1	-	1	1	1	-	-
5.00 and above	-	-	-	-	-	-	-
Average Net Return[b] (Rs/Rs of N)	1.33	-0.04	0.17	0.37	2.06	1.51	0.0
Total trials	9	18	7	4	2	3	2
Significant trials	7	9	2	1	2	1	-
			30-34 kg N/ha				
Mean response[a] (Kg/Kg of N)	11.3	5.4	-	-	4.7	5.8	0.0
Coefficient of variation of response[a] (%)	45	58	-	-	124	-	-
Net Return/Rs of N[b]:							
Less than 0.00	-	5	-	1	2	-	-
0.00 - 0.99	1	2	-	-	-	-	-
1.00 - 1.99	-	9	-	-	1	2	-
2.00 - 2.99	3	7	-	-	-	-	-
3.00 - 4.99	3	-	-	1	1	-	-
5.00 and above	2	-	1	-	-	-	-
Average Net Return[b] (Rs/Rs of N)	3.32	1.11	-	-	0.85	1.27	-1.00
Total trials	9	23	1	2	4	2	-
Significant trials	9	19	1	1	2	2	-

a Based on significant responses only
b See footnote b, Table 1

Table 5. Frequency distribution of marginal net returns per rupee of nitrogen on rainfed chickpea for two soils[a]

	20-24 Kg N/ha over 5-14 Kg N/ha		30-34 Kg N/ha over 20-24 kg N/ha	
	Alluvial	Medium Black	Alluvial	Medium Black
Less than 0.00	1	2	-	1
0.00 - 0.99	-	-	1	-
1.00 - 1.99	-	-	1	-
2.00 - 2.99	1	1	-	2
3.00 - 4.99	1	4	-	3
5.00 and above	1	-	2	-
Total trials	4	7	4	6
Significant trials	4	5	4	5

a Other soil types did not have enough data for meaningful analysis.

Table is based on experiments with significant incremental responses only.

Table 6. Mean response and frequency distribution of average net returns per rupee of nitrogen applied to irrigated chickpea at various levels of nitrogen

	Levels of Nitrogen (Kg N/ha)					
	5-14	15-19	20-24	25-29	30-34	>35
Mean response[a] (Kg/Kg of N)	15.1	2.4	1.6	-1.9	3.8	1.7
Coefficient of variation of response[a] (%)	130	264	401	390	150	199
Net Return/Rs of N[b]:						
Less than 0.00	3	6	6	5	4	3
0.00 - 0.99	-	-	2	-	1	2
1.00 - 1.99	-	-	-	-	-	-
2.00 - 2.99	-	-	-	1	-	1
3.00 - 4.99	-	-	1	-	2	-
5.00 and above	3	1	-	-	-	-

a Based on significant responses only
b See footnote b, Table 1

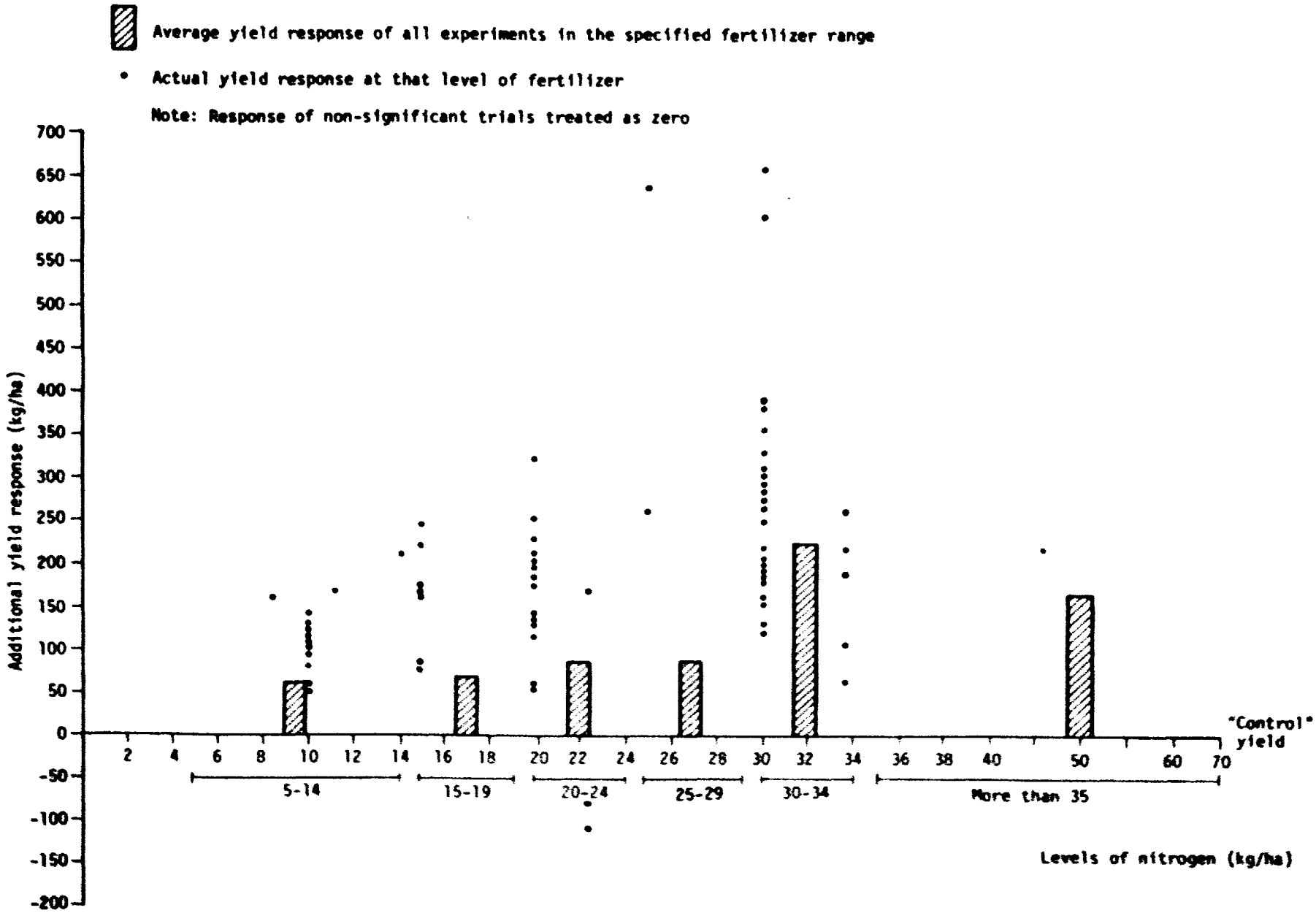

Fig. 2. Yield response of rainfed chickpea to nitrogen over control.

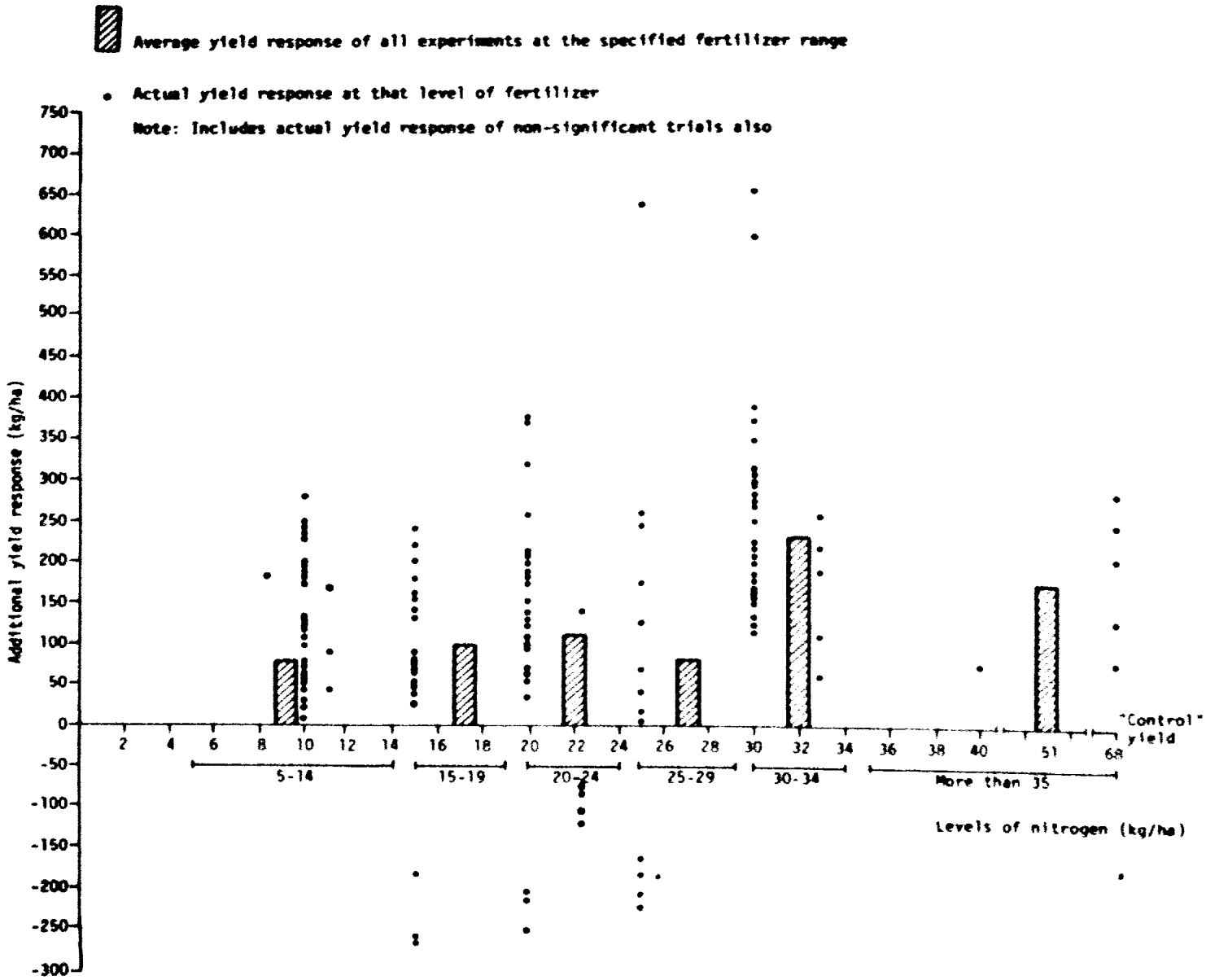

Fig. 3. Yield response of rainfed chickpea to nitrogen over control.

Research Project under rainfed conditions found a dose of 20 kg N/ha to be quite beneficial in 12 out of 16 trials where the benefit/cost ratio exceeded 2.(Kulkarni 1980).3

The analysis of marginal net returns (Table 3) also established that on average it pays to extend the level of application from 5-14 kg to 20-24 kg N/ha. When this is done 73% of the trials showed a marginal net return/cost ratio greater than 2, and 27% of trials generated marginal losses. A further increase in the rate of application to 30-34 kg N/ha is also reasonably attractive, with 64% of trials giving a marginal net return/cost ratio greater than 2, only 14% of trials giving marginal net losses, and 36% giving marginal net returns less than 2. We did not work out the marginal returns for the highest level (35 kg N) because this level showed poor average returns.

The mean yield responses to nitrogen on alluvial soils were 6.0 kg and 11.3 kg with 20-24 kg N/ha and 30-34 kg N/ha respectively, whereas the corresponding responses on medium black soils were 2.4 kg and 5.4 kg respectively, the latter soil type showing a very high variation in response at the 20-24 kg N/ha level (Table 4). Nearly 83 percent of the trials in medium black soils and all the trials in alluvial soils gave significant responses with 30-34 kg N/ha. Thirty percent of these trials in medium black soils and 84 percent of the trials in alluvial soils had average net return/cost ratio exceeding 2. The marginal analysis also suggested that it is profitable on both alluvial and medium black soils to apply up to 30-34 kg N/ha (Table 5). Most of the studies at ICRISAT Center concluded that there was no yield response to nitrogen, in Alfisols and deep Vertisols, though there was marked improvement in seedling growth (Krantz et al. 1974).

ii) Irrigated Chickpea

The mean yield response of chickpea under irrigated conditions showed variations from 1.7 to 15 kg per kg of N. Meaningful responses were obtained only at the 5-14 kg and 30-34 kg N/ha levels (Tables 1 and 6, and Figure 4).

On average 45% of trials under irrigated conditions gave statistically significant responses. Only nitrogen levels of 5-14 kg/ha gave reasonable average net returns of Rs. 4.92 per Re. of N. However, this was achieved with a 50% risk of losses. At higher levels of N the percentage of losses seems to be higher. It is thus doubtful from this admittedly limited amount of evidence whether application of nitrogen to irrigated chickpea is worthwhile.

Returns to Phosphorus

The response to phosphorus was comparable in 144 experiments and most of them (71 percent) were under rainfed conditions. As with the N trials,

3. See Appendix Table 1 for details of these experiments.

about half of the phosphorus trials had basal doses of N and half did not. Though phosphorus has significant influence on chickpea yield, the average response does not seem to be as high as for nitrogen.

i) Rainfed Chickpea

The average yield response of rainfed chickpea increased from 48 kg/ha with 5-19 kg P_2O_5/ha to 378 kg/ha with 60-79 kg P_2O_5/ha (Figure 5). The increasing trend was observed when the actual response of non-significant trials were also included (Figure 6). The percentage of trials generating economic losses was a maximum at 40-59 kg P_2O_5/ha, whereas with other levels it was less (Table 7). The variation in mean response was more than 80 percent with respect to phosphorus and the average response was 4.8 kg/kg of P_2O_5 with 20-39 kg P_2O_5/ha and 5.5 kg with 60-79 kg P_2O_5/ha. At higher levels of phosphorus the variation in yield responses was less than at lower levels (Table 8). The influence of phosphorus on yield was supported by most of the studies, which concluded that a significant response occurs within a range of 30-60 kg P_2O_5/ha.

The highest average net return per rupee spent on phosphorus was at the >80 kg P_2O_5/ha level, irrespective of the methods used. However, this is based on so few observations that more confidence can be placed on specifying the 60-79 kg P_2O_5/ha as giving the best average net return.

The data suggests that 64% of the trials with 20-39 kg P_2O_5/ha showed significant yield responses. The percentage for the 60-79 kg P_2O_5/ha level was 85. But in terms of profitability, only 20% of the trials with 20-39 kg P_2O_5/ha and 60-79 kg P_2O_5/ha gave an average net return over 2 (Table 8).

In terms of marginal net returns, even though 95% of the trials with 60-79 kg P_2O_5/ha gave significant marginal net returns over 20-39 kg P_2O_5/ha only 21% of the trials gave profitable marginal returns (Table 9). In alluvial soils the 60-79 kg P_2O_5/ha level always gave significant marginal net returns over the 20-39 kg P_2O_5/ha level. In medium black soils the figure was almost 90%. In terms of profitability though only in alluvial soils were the returns economical (31% of the significant trials), whereas in medium black soils all the trials showed marginal returns of less than 1.

On an average 87% of the trials in alluvial soils and 54% of trials in medium black soils gave a significant response to phosphorus (Table 10) in both soils though the variation in response was high with 20-39 kg P_2O_5/ha, and the response was poor in medium black soils. Pandey (1969) suggested that reduction in yield at higher levels of phosphorus may be because root nodule formation may be checked at higher concentrations. This could be a promising area for further research.

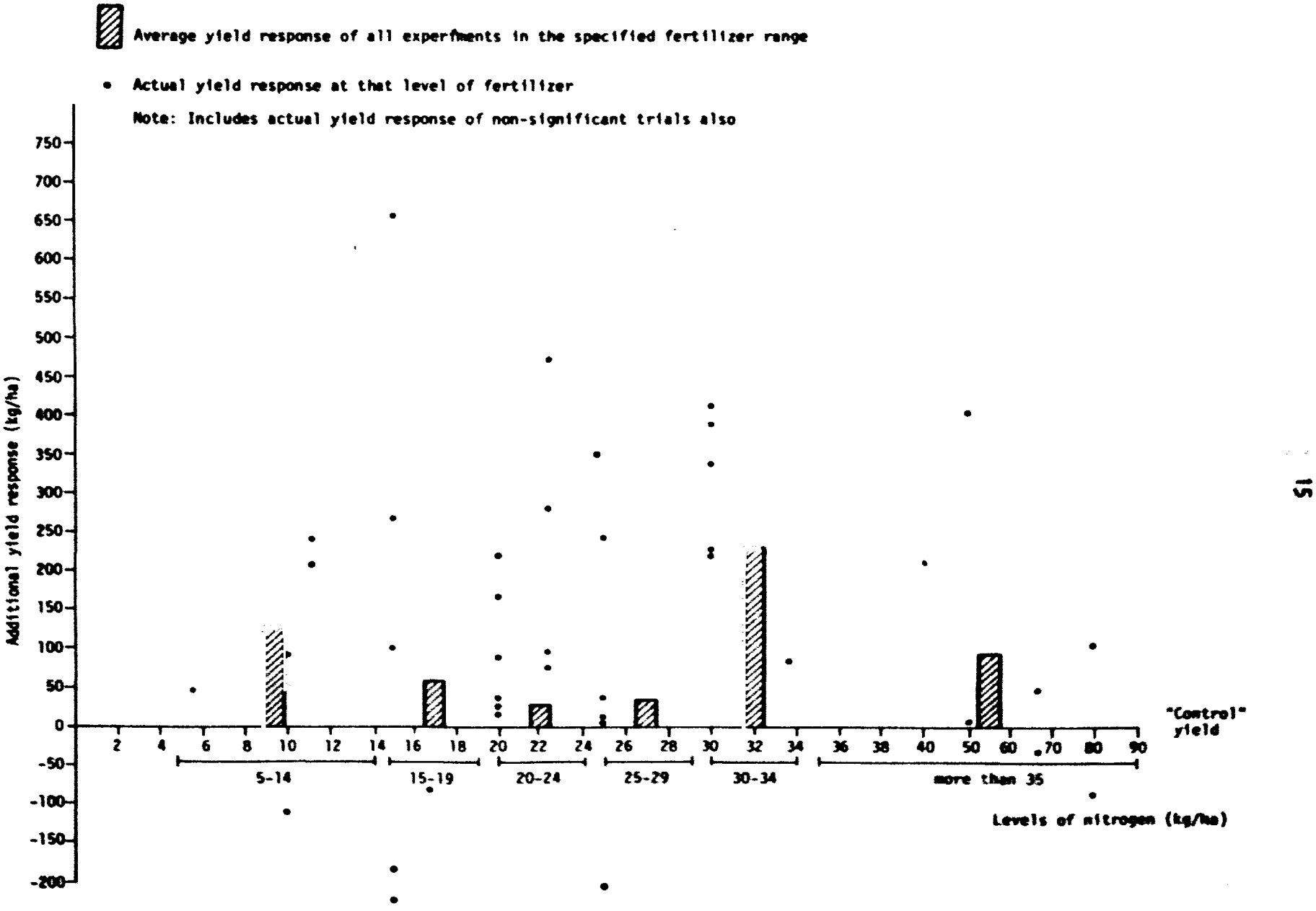

Fig. 4. Yield response of irrigated chickpea to nitrogen over control.

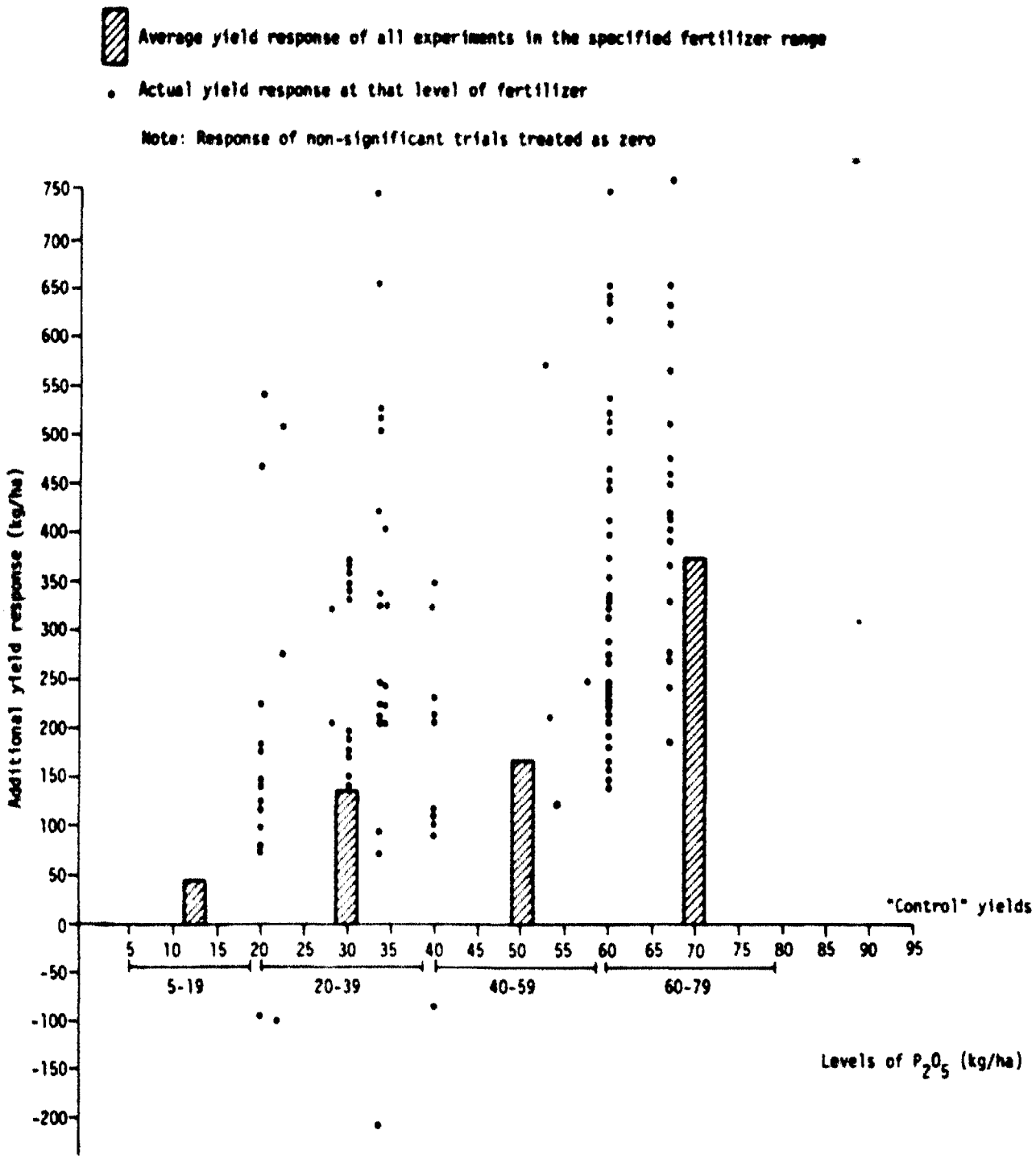

Fig. 5. Yield response of rainfed chickpea to phosphorus over control.

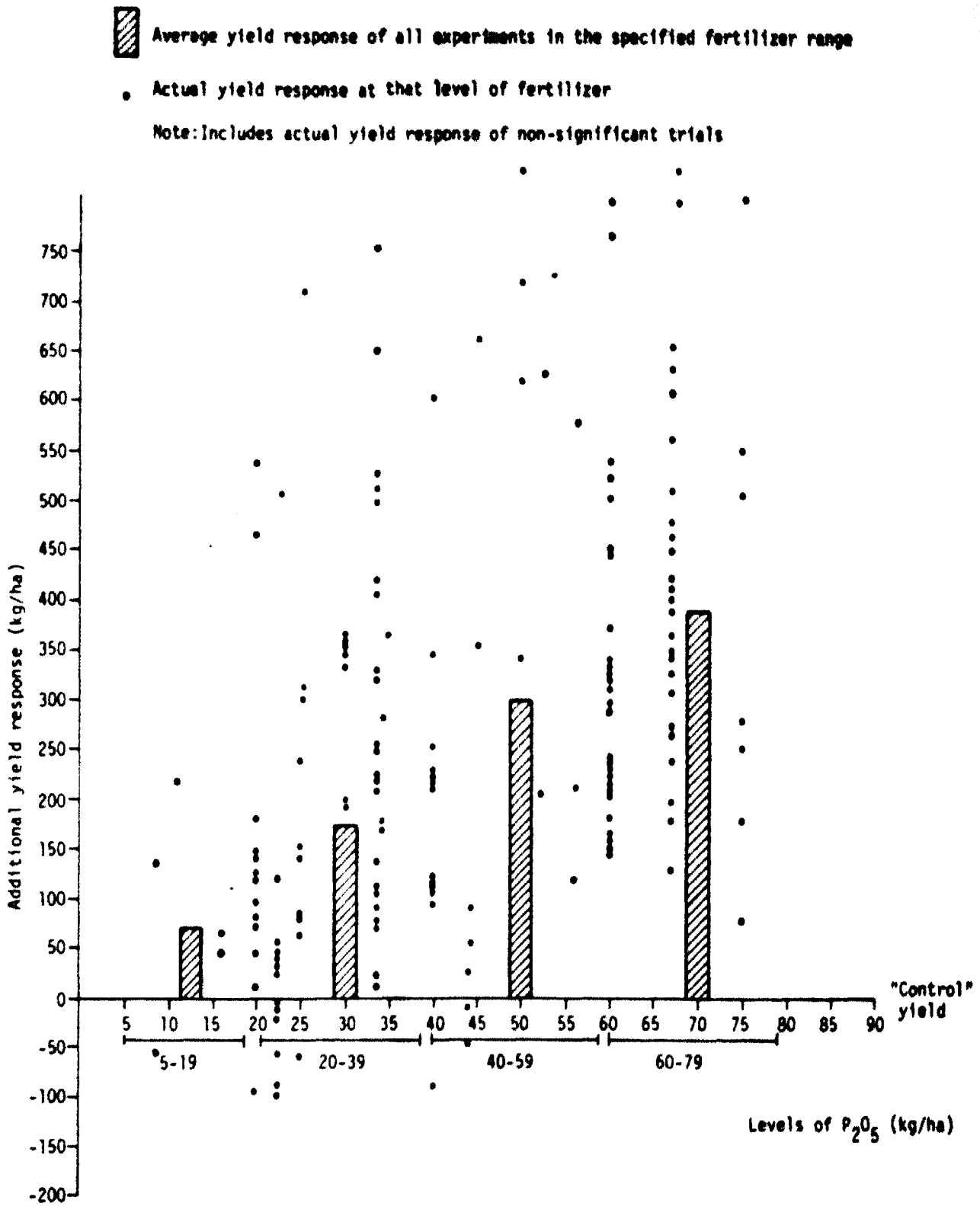

Fig. 6. Yield response of rainfed chickpea to phosphorus over control.

Table 7. Average net returns per rupee at various levels of Phosphorus

	Levels of Phosphorus (Kg P_2O_5/ha)				
	5-19	20-39	40-59	60-79	>80
			RAINFED		
Number of trials	8	97	33	66	3
Significant trials	2	62	13	56	3
Average net return (Rs/Rs of P_2O_5) with:					
i) Significant responses only	6.02	1.75	0.34	1.40	4.80
ii) Significant trials plus actual value of non-significant trials	1.15	0.98	0.43	1.17	4.80
iii) Significant trials plus non-significant response treated as zero	0.76	0.88	0.71	1.16	4.95
Percentage of economic losses[a]	75	43	82	23	0
			IRRIGATED		
Number of trials	3	49	28	33	6
Significant trials	-	19	11	18	4
Average net return (Rs/Rs of P_2O_5) with:					
i) Significant responses only	-	1.83	1.32	0.91	0.01
ii) Significant responses plus actual value of non-significant trials	-1.30	0.44	0.45	0.17	-0.36
iii) Significant responses plus non-significant response treated as zero	-1.00	0.10	-0.06	0.06	-0.34
Percentage of economic losses[a]	100	67	71	55	67

a See footnote b, Table 1

Table 8. Mean response and frequency distribution of average net returns per rupee of phosphorus applied to rainfed chickpea at various levels of phosphorus

	Levels of Phosphorus (Kg P_2O_5/ha)				
	5-19	20-39	40-59	60-79	>80
Mean response[a] (Kg/Kg of P_2O_5)	4.5	4.8	1.8	5.5	15.2
Coefficient of variation response[a] (%)	186	122	186	80	6
Net Return/Rs of N[b]:					
Less than 0.00	6	42	27	15	-
0.00 - 0.99	-	14	3	24	-
1.00 - 1.99	-	22	-	14	-
2.00 - 2.99	-	6	2	6	-
3.00 - 4.99	-	6	1	4	-
5.00 and above	2	7	-	3	3

a Based on significant responses only
b See footnote b, Table 1

Table 9. Frequency distribution of marginal net returns of 60-79 kg P_2O_5/ha over 20-39 Kg P_2O_5/ha on rainfed chickpea grown on various soils[a]

	Total No. of trials	Alluvial	Medium Black	Calcareous Sierozome	Red and Yellow
Less than 0.00	9	1	6	1	1
0.00 - 0.99	13	9	3	-	1
1.00 - 1.99	9	8	-	-	1
2.00 - 2.99	2	2	-	-	-
3.00 - 4.99	1	1	-	-	-
5.00 and above	5	5	-	-	-
Total trials	39	26	9	1	3
Significant trials	37	26	8	1	2

a. Based on experiments with significant incremental responses only.

Table 10. Mean response and frequency distribution of average net returns per rupee of phosphorus on rainfed chickpea based on soil classification.

	Alluvial	Medium Black	Red & Black	Red & Yellow	Mixed RB & RY	Calcareous Sierozem
			20-39 Kg P_2O_5/ha			
Mean responses[a] (Kg/Kg of P_2O_5)	6.7	3.0	0.7	2.9	0.0	6.3
Coefficient of variation of response[a] (%)	90	179	283	173		5.4
Net return/Rs of P_2O_5[b]:						
Less than 0.00	10	19	7	4	2	--
0.00-- 0.99	4	9	-	1	-	-
1.00 - 1.99	12	6	1	1	-	3
2.00 - 2.99	3	3	-	-	-	-
3.00 - 4.99	8	3	-	-	-	-
5.00 and above	2	1	-	-	-	-
Average net return[b] (Rs/Rs of P_2O_5)	1.62	0.18	-0.73	0.14	-1.00	1.47
Total trials	39	39	8	6	2	3
Significant trials	34	21	1	3	-	3
			60-79 kg P_2O_5/ha			
Mean response[a] (Kg/Kg of P_2O_5)	7.4	3.5	-	4.2	3.0	2.8
Coefficient of variation of response[a] (%)	58	53	-	182	-	-
Net returns/Rs of P_2O_5[b]:						
Less than 0.00	1	5	-	4	1	1
0.00 - 0.99	9	11	-	1	1	2
1.00 - 1.99	11	3	-	-	-	-
2.00 - 2.99	6	-	-	-	-	-
3.00 - 4.99	3	-	-	1	-	-
5.00 and above	3	-	-	-	-	-
Average net return[b] (Rs/Rs of P_2O_5)	1.90	0.37	-	0.65	0.18	0.10
Total trials	33	19	-	6	2	3
Significant trials	32	17	-	3	2	2

a Based on significant responses only
b See footnote b, Table 1

ii) Irrigated Chickpea

The variation of mean response of irrigated chickpea to phosphorus was very high (more than 80%) at all levels of phosphorus. The maximum response of 2.8 kg/kg of P_2O_5 was obtained with 20-39 kg P_2O_5/ha (Table 11 and Figure 7).

Under irrigated conditions it appears that application of 20-39 kg P_2O_5/ha alone gave positive returns. At this level of fertilizer application 39% of the trials gave a significant response, out of which 37% gave profitable returns. However, two-thirds of the trials generated losses at this level of P_2O_5. Though 55% of trials gave significant responses with 60-79 kg P_2O_5/ha, only 11% gave profitable returns and 55% gave losses (Table 11). Mixed red and black, and red and yellow soils gave fairly good average returns at 20-39 kg P_2O_5/ha (Table 12). Here too the probability of losses was high though, at more than 67%.

Response to interactions

Even though 67 experiments were conducted to determine the interaction effects among nitrogen, phosphorus and potassium, the levels were comparable only in 23 experiments. In these 23 experiments it was not possible to draw any conclusive inferences. Also, most of the studies were limited to a period of 1 to 2 years and the stability over time and over varieties was not clear.

Conclusions

The major conclusions of this review can be summarised as follows:

- There was enough evidence to suggest that use of 30-34 kg N/ha was profitable for rainfed chickpeas, particularly on alluvial soils.

- Nitrogen applications on irrigated chickpeas do not appear profitable.

- With respect to phosphorus on rainfed chickpea, statistically significant yield responses were observed in a large number of trials. In very few cases was the net returns per rupee of investment greater than 2, and loss probabilities were high surprisingly, the case for phosphatic fertilization of chickpea is weaker than that for the use of nitrogenous fertilizers at prices prevailing in the mid-1970's.

  Phosphorus applications on rrigated chickpea do not appear profitable.

Table 11. Mean response and frequency distribution of average net returns per rupee of phosphorus applied to irrigated chickpea at various levels of phosphorus

	Levels of phosphorus (Kg P_2O_5/ha)				
	5-19	20-39	40-59	60-79	>80
Mean response[a] (Kg/Kg of P_2O_5)	0.0	2.8	2.4	2.7	1.7
Coefficient of variation of response[a] (%)	-	101	160	153	131
Net returns (Rs/Rs of P_2O_5)[b]:					
Less than 0.00	3	33	20	18	4
0.00 - 0.99	-	4	2	8	1
1.00 - 1.99	-	5	3	5	1
2.00 - 2.99	-	3	-	-	-
3.00 - 4.99	-	3	3	1	-
5.00 and above	-	1	-	1	-
Percentage of economic losses[b]	100	67	71	55	67

a Based on significant responses only
b See footnote b, Table 1.

Table 12. Mean response and frequency distribution of net return per rupee of phosphorus based on soil classification on irrigated chickpea

	Alluvial	Medium Black	Red & Black	Mixed Red Black and Red yellow	Taral	Desert	Calcareous Sierozems
				20-39 Kg P_2O_5/ha			
Mean response[a] (Kg/kg of P_2O_5)	3.1	2.0	5.5	7.4	0.0	4.2	0.0
Coefficient of variation of response[a] (%)	262	143	-	110	-	169	-
Net return/Rs of P_2O_5[b]:							
Less than 0.00	7	12	1	2	5	5	1
0.00 - 0.99	-	2	-	1	-	1	-
1.00 - 1.99	-	4	-	1	-	-	-
2.00 - 2.99	-	-	2	-	-	1	-
3.00 - 4.99	2	-	-	1	-	-	-
5.00 and above	-	-	-	-	-	1	-
Average net return[b] (Rs/Rs of P_2O_5)	0.21	-0.22	1.16	1.9	-1.00	0.72	-1.00
Total trials	9	18	3	5	5	8	1
Significant trials	4	7	2	3	-	3	-
				60-79 Kg P_2O_5/ha			
Mean response[a] (Kg/kg of P_2O_5)	2.0	1.5	5.9	4.9	-0.9	9.8	0.7
Coefficient of variation of response[a] (%)	-	139	-	-	-	-	-
Net return/Rs of P_2O_5[b]:							
Less than 0.00	2	10	-	-	5	-	1
0.00 - 0.99	-	4	1	1	-	1	1
1.00 - 1.99	-	1	2	1	-	1	-
2.00 - 2.99	-	-	-	-	-	-	-
3.00 - 4.99	1	-	-	-	-	-	-
5.00 and above	-	-	-	-	-	1	-
Average net return[b] (Rs/Rs of P_2O_5)	-0.22	-0.42	1.31	0.92	-1.35	2.84	-0.3
Total trials	3	15	3	2	5	3	2
Significant trials	1	6	3	2	1	3	2

a Based on significant trials only
b See footnote b, Table 1

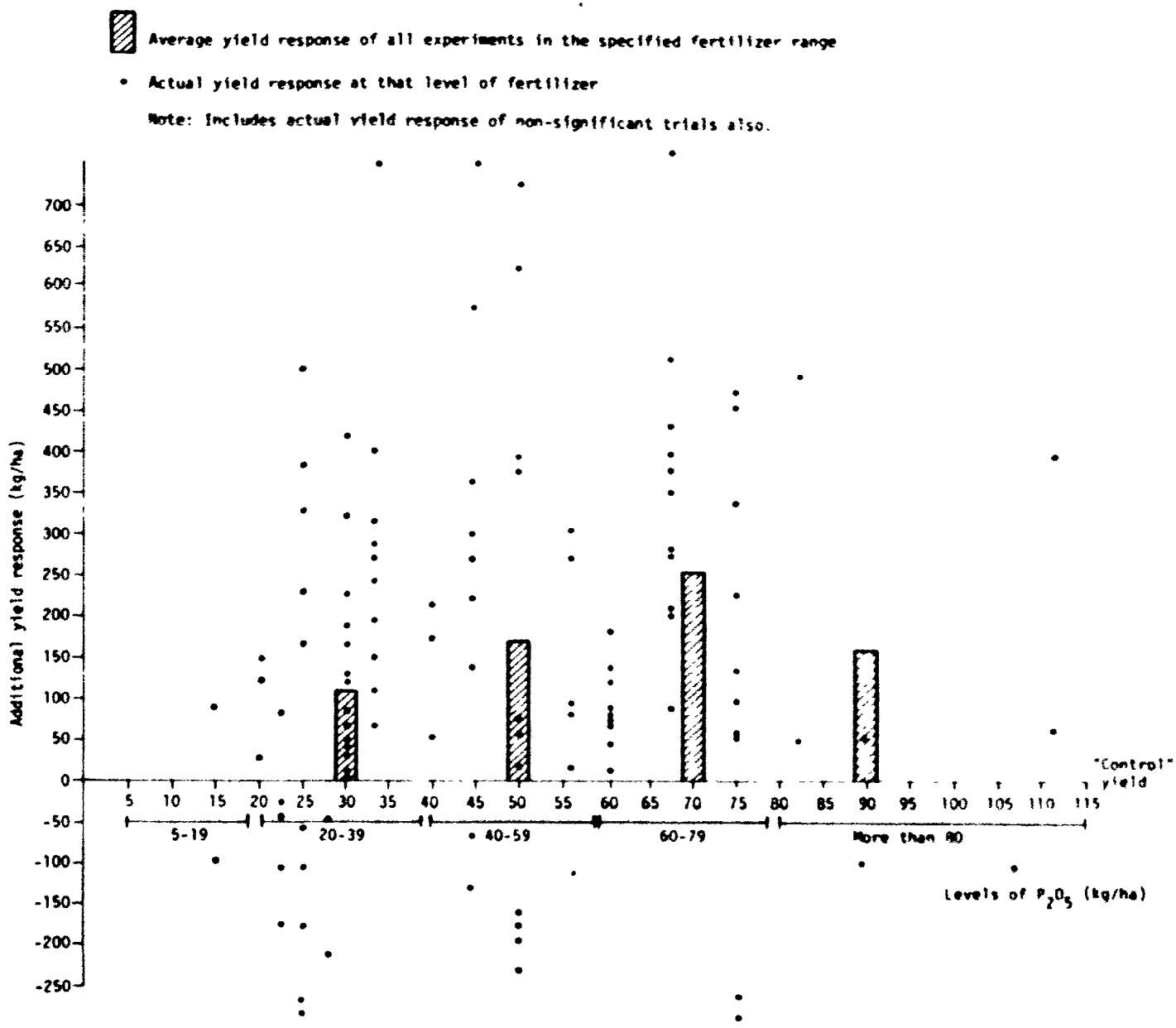

Fig. 7. Yield response of irrigated chickpea to phosphorus over control.

References

Ahmad, N., and Jha, K.K. 1977. Effect of inoculation with Phosphate solubilising organisms on the yield and P uptake of gram. Journal of the Indian Society of Soil Science, 25(4):391-393.

Aulakh, M.S., Pasricha, N.S., and Dev, G. 1977. Response of different crops to Sulphur fertilization in Punjab. Fertilizer News, 22(9): 32-36.

Bajpai, P.B., Lehri, L.K., and Tewari, V.N. 1973. Effect of Nitrogen and inoculation on yields of Bengal gram. Some Microbiological studies on rabi pulses. All India Coordinated Research Project on Pulses. Proceedings of the 10th Workshop:175.

Bhandari, A.L., Meelu, O.P., and Randhawa, N.S. 1972. Response of gram to different Phosphatic fertilizers. Progressive Farming 8(12):18-19.

Bisen, C.R., and Kashyap, M.L. 1974. Response of gram (JG-22) to inoculation and fertilization under different moisture supply. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:304.

Bisen, C.R., and Kashyap, M.L. 1974. Yield potential of gram varieties under high input conditions. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:368.

Bisen, C.R., and Kashyap, M.L. 1976. Studies on the effect of rabi pulses on the fertilizer requirements of kharif cereals. Results of the coordinated trials conducted during rabi 1976-77. All India Coordinated Pulse Improvement Project. ICAR:New Delhi.

Choudhary, B., Verma, V.K. 1974. A note on the effect of methods of Phosphate application on the yield of rainfed gram. Proc. Bihar Acad. Agri. Sciences 22-23(106).

Chowdhury, S.L. 1969. Pulse crops more productive than you think. Indian Farming:19(6):23-26.

Chowdhury, S.L., and Sharma, B.M. 1971. Effect of stage-bound irrigation, inter-row spacing and fertilization of the yield of gram (var. C.235). Results of the Agronomic investigations on pulses conducted during 1969-70 at IARI. All India Coordinated Research Project on Pulses. Proceedings of the 5th Workshop:69-71.

Chowdhury, S.L., and Sewa Ram and Giri Gajendra. 1975. Effect of P and N and inoculum on root nodulation and yield of gram. Indian Journal of Agron:20(3):290-291.

Chowdhury, S.L., Bhatia, P.C., Sharma, B.M., and Singh, K. 1971. Yield potentials of Bengal gram (Cicer arietinum). Indian Journal of Agron. 16(3):296-299.

Chowdhury, S.L., Davies, R.G., Bhatia, P.C., and Sharma, B.M. 1968. Fertility cum inoculum trial on gram. Half yearly Report. Division of Agron, IARI:New Delhi:32.

Chowdhury, S.L., Davies, R.G., Bhatia, P.C., and Sharma, B.M. 1968. Response of gram to levels of N, P and K and methods of application. Half yearly Reports. Division of Agron, IARI: New Delhi:33.

Chundawat, G.S., Sharma, R.G., and Shehawat, G.S. 1976. Effect of Nitrogen, Phosphorus, and bacterial fertilization on growth and yield of gram in Rajasthan. Indian Journal of Agron. 21(2):127-130.

Dhillon, D.S., Kler, D.S., Walia, A.S., Chahal, V.P.S., and Gupta, R.P. 1977. Effect of Molybdenum in relation to Rhizobuim culture on the yield of some pulse crop. Indian Journal of Agron. 22(3):170-171.

Directorate of Extension and Training, Ministry of Agriculture. 1972. Proper Management Practices can Double Pulse yield. Fertilizer News. 17(9):49.

Gajendra Giri and Rajat De. 1974. Economics of fertilizer use under rainfed conditions. Fertilizer News 19(10):20-21.

ICAR. 1970. Fertilizer use in dryland agriculture for legumes. All India Coordinated Research Project for Dryland Agriculture. Progress Report:20-21.

ICAR. 1970. Fertilizer use in dryland agriculture for gram in Indore. All India Coordinated Research Project for Dryland Agriculture Progress Report:28-29.

ICAR. 1970. Fertilizer use in dryland agriculture of gram in Rewa. All India Coordinated Research Project for Dryland Agriculture Progress Report:32.

ICAR. 1971. Simple Fertilizer Trials - Dry Farming Programme, Type. D trials. All India Coordinated Agronomic Experiments Scheme Annual Report: 442-471.

ICAR. 1972. Simple fertilizer trials on cultivators' fields. Dry farming programme type-D trials. All India Coordinated Agronomic Experiments Scheme Annual Report:518-549.

ICAR. 1973. Response of gram to fertilizers under dryland conditions. All India Coordinated Agronomic Experiments Scheme Annual Report 49:184-185.

ICAR. 1974. Responses of Gram and Tur to fertilizers under dryland conditions. All India Coordinated Agronomic Experiments Scheme Annual Report:310-313.

ICAR. 1975. The response of different crops to the fertilizer application under dryland conditions. All India Coordinated Agronomic Experiments Scheme Annual Report:61-65, 328-335.

ICAR. 1975. Relative gross income from different crops in drylands in relation to fertilizer application. All India Coordinated Agronomic Experiments Scheme Annual Report:65-68.

ICAR. 1978. All India Coordinated Soil Test Crop Response Correlation Project. Fertilizer News 23(8):28.

ICAR. 1974. Response of crops to varying levels of Nitrogen and Phosphorus review of rabi crops yield data. All India Coordinated Research Project on Dryland Agriculture, Hyderabad:15-18.

ICAR. 1974. Efficiency of methods of applying P_2O_5 to crops. Review of kharif yield data. All India Coordinated Research Project on Dryland Agriculture.

Institute of Agricultural Research Statistics. 1954. National Index of agricultural field experiments, Andhra Pradesh, Vol 1, Part 2, ICAR:New Delhi.

Institute of Agricultural Research Statistics. 1954 N.I.A.F.E Gujarat vol.4, Part 2. ICAR:New Delhi.

Institute of Agricultural Research Statistics. 1954 N.I.A.F.E Madhya Pradesh vol:6, Part 2. ICAR:New Delhi.

Institute of Agricultural Research Statistics. 1954. N.I.A.F.E Maharashtra vol:8, Part 2. ICAR:New Delhi

Institute of Agricultural Research Statistics. 1954 N.I.A.F.E Mysore vol:9, Part 2. ICAR New Delhi.

Institute of Agricultural Research Statistics. 1954 N.I.A.F.E. Punjab, Haryana vol:11, Part 2. ICAR:New Delhi

Institute of Agricultural Research Statistics. 1954 N.I.A.F.E. Rajasthan vol:12, Part 2. ICAR:New Delhi.

Institute of Agricultural Research Statistics. 1954 N.I.A.F.E Uttar Pradesh vol:13, Part 2. ICAR:New Delhi.

Kaul, J.N. 1974. Studies on the agronomic management of gram (c. 214) under rainfed conditions. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop 307.

Kaul, J.N., and Sekhon, H.S. 1974. Response of gram (G. 130) to inoculation and fertilization under different moisture supply. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop 300.

Khedkar, P.K. 1972. Response of gram to inoculum and nitrogen application and rates and methods of phosphorus application under rainfed conditions. Annual Report of Rabi Pulses Research in Agronomy at Badnapur. All India Coordinated Research Project on Pulses. Proceedings of the 8th Workshop:176-180.

Krantz, B.A., Kampen and Sharma, S.K. 1973. Fertilization and inoculum studies on chickpea. First Annual Report of the ICRISAT Research Program 56 58-59.

Krantz, B.A., Kampen and Associates. 1974. Effect of phosphorus and nitrogen application on chickpea with and without inoculum. Annual Report of the ICRISAT Farming Systems Research Program 35-36.

Krantz, B.A., Kampen, and Associates. 1974. The effect of foliar applicants of Urea upon the yields of 2 chickpea varieties. Annual Report of the ICRISAT Farming System Research Program 36-37.

Kulkarni, K.R. 1980. Scope for increasing production of pulses through use of fertilizers under rainfed condition and its economics. Fertilizer News 25(8) 3-11.

Lakhdive, B.A. and Marge, J.B. 1976. Effect of placement of fertilizers on the yield of Desi Gram. Food Farming and Agriculture 8(5) 22.

Luthra, R.C. and Gill, A.S. 1974. Effect of sowing dates, seed rates and phosphorus on the yield of gram. J. Research, Ludhiana 11(4) 355-358.

Maharanobish, J.K. and Roy, D.R. 1975. A study on fertilizer requirement of gram in Tripura. Fm J, Calcutta 16(9) 15-18.

Mahapatra, I.C., Bapat, S.R., Sardana, M.G., and Bhendia, M.L. 1973. Fertilizer response of wheat, gram and horsegram under rainfed conditions. Fertilizer News 18(4) 57-63.

Mahapatra, I.C., Rajendra Prasad and Bapat, S.R. 1973. Fertilizers pay well even under dryland conditions. Indian Fmg. 23(3) 15-20.

Maheshwari, S.K. and Laxman Singh. 1976. Effect of varying fertility level and plant spacing on yield of two varieties of Bengal gram (Cicer arietinum L.). JNKVV Research Journal 10(1) 508.

Manji, Shankar. 1968. Response of gram to varying levels of phosphorus alone and in combination with nitrogen and potassium applied broadcast and at plough sole. Unpublished M.Sc. (Agri.) thesis. Division of Agronomy, IARI:New Delhi.

Manjhi, Shankar., and Chowdhury, S.L. 1971. Response of Bengal gram (Cicer arietinum) to four levels of phosphorus applied alone and in combination with Nitrogen and Potassium. Indian Journal of Agron. 16(2):247-249.

Mathiu, O.P., Choudhary, V.S., and Tomar, P.S. 1973. Response of gram to varying levels of irrigation and phosphorus in Western Rajasthan. Rajasthan Journal of Agril. Sci. 4(1):45-49.

Matin, M.A., and Ram, A. 1974. Effect of different level of phosphate applied by different methods on the rooting, nodulation and yield of gram (Cicer arietinum). Proceedings of the Bihar Academy of Agricultural Sciences, XXII-XXIII:35-39.

Mishra, S.S., and Ram, A. 1971. Tilth, Nitrogen and method of Phosphate application in relation to gram yield. Fertilizer News 16(10):65-71.

Moolani, M.K. 1966. Effect of N, P fertilization on growth and yield of gram. Ann. Arid Zone 5(2):127-133.

Nema, V.P. 1973. Response of inoculation, Nitrogen and Phosphate fertilisation on gram. Report of the Agronomic Experiment on Rabi Pulses at Sub-Centre JNKVV Campus Sehore 1972-73. All India Coordinated Research Project on Pulses. Proceedings of the 10th Workshop:158-159.

Nema, V.P. 1974. Studies of the Agronomic Management of gram under rainfed conditions. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:310.

Pandey, S.N. 1969. Effect of nitrogen, phosphorus, potassium and molybdenum on nodule formation. Indian Journal of Agronomy 14(2):205-207.

Pawar, K.S. 1974. Response of gram variety T.3 to inoculation and fertilization under different moisture supply at Kanpur. All India Coordinated Research Projects on Pulses. Proceedings of the 12th Workshop:303.

Pawar, K.S., Singh, Y.P., Singh, V.V., and Misra, A.S. 1977. Response of gram, lenthel and field peas to inoculation and levels of Nitrogen and Phosphorus. Indian Journal of Agron. 22(3):145-148.

Raikhelkar, S.V., Quadri, S.J., and Bagade, D.N. 1977. Irrigation and fertilizer requirement of gram (Cicer arietinum L.). J. Maharashtra Agri. Universities 2(2):144-146.

Rajendra Prasad, Bhendla, M.L., and Bains, S.S. 1968. Response of Grain legumes to levels and sources of Phosphorus on different soils. Indian Journal of Agron. 13(4):305-309.

Ramanujam, S. 1973. All India Coordinated Project for Research on Improvement of pulses. Fertilizer News 18(11):25-28.

Randhawa, N.S., and Takkar, P.N. 1975. Micro Nutrient Research in India. The present status and future projections. Fertilizer News 20(5) 11-18.

Rao, Prabhanjar, S.B., Ramanath, B., and Sam, M.J. 1973. Response of gram to fertilizer application in the black cotton soils of Bellary under dryland farming. Mysore Journal of Agric. Sci. 7(3):360-364.

Rao, Prahlad, G. 1974. Response of gram (BEG 482) to inoculation, fertilization, under different moisture supply at Rajendranagar. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:305.

Rathi, S.S., and Singh, D. 1976. Effect of Nitrogen and Phosphate fertilization on the growth and yield of gram. Indian Journal of Agron. 21(3):305.

Ryan, J.G., and M. Asokan. 1977. Effect of green revolution in wheat on production of pulses and nutrients in India. Economics Program Occasional paper 18. ICRISAT, Hyderabad.

Roy Sharma, R.P. 1974. Response of Gram (C. 235) to inoculation and fertilization under different moisture supply at Dholi. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop 304.

Roy Sharma, R.P. 1974. Studies on the agronomic management of gram under rainfed conditions at Dholi. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:311.

Saraf, C.S. 1974. Response of gram to inoculation and Phosphorus under varying moisture conditions at New Delhi. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:299.

Saraf, C.S., Ahlawat, I.P.S., Singh, A., Turkhede, B.B., and Ganga Saran. 1976. Studies on agronomic management on gram under rainfed conditions. Half yearly Reports. Division of Agronomy. IARI:New Delhi:66

Sarnaik, N.T. 1974. Response of gram (Chaffa) to inoculation and fertilization under different irrigation intervals at Badnapur. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:306.

Sarnaik, N.T. 1974. Studies on the agronomic managements of gram under rainfed conditions. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:312.

Saxena, M.C., and Singh, H.P. 1970. Response of Gram varieties to Nitrogen fertilization and inoculation. G.B. Pant University of Agriculture and Technology. Research in Progress. Annual Report:150-151.

Saxena, M.C., and Singh, H.P. 1974. Response of gram (C.235) to inoculation and fertilization under different moisture supply at Pantnagar. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop: 302.

Saxena, M.C., and Singh, H.P. 1974. Studies on the agronomic managements of gram under rainfed conditions at Pantnagar. All India Coordinated Research Project on Pulses. Proceedings of the 12th Workshop:308.

Saxena, M.C., and Singh, H.P. 1975. Response of gram to inoculation and fertilization under different moisture supply. Annual Report of Research. G.B. Pant University of Agriculture and Technology:25.

Saxena, M.C., Singh, H.P., and Mishra, O.P. 1975. Response of gram to inoculation Nitrogen and Phosphorus application. Annual Report of Research G.B. Pant University of Agriculture and Technology:24.

Saxena, M.C., Singh, H.P., Yadav, D.S., and Sharma, R.P. 1974. Response of gram (G. 130) to inoculation and fertilization under different moisture conditions. Annual Report of Research. G.B. Pant University of Agriculture and Technology:22.

Saxena, M.C., and Yadav, D.S. 1973. Response of gram to different levels of Nitrogen and Phosphorus application. Report of the Work done on the rabi pulses agronomy at Pantnagar during 1972-73. All India Coordinated Research Project on Pulses. Proceedings of the 10th Workshop:132.

Saxena, M.C., Yadav, D.S., and Sharma, R.P. 1972. Response of gram to Nitrogen, inoculation and Phosphorus. G.B. Pant University of Agriculture and Technology. Annual Report 1972-73 and 1973-74:75.

Saxena, M.C., Yadav, D.C., and Singh, N.P. 1971. Response of gram varieties to inoculation and Nitrogen application. Annual Report of Research. G.B. Pant University of Agriculture and Technology:153.

Saxena, M.C., Yadav, D.C., and Singh, N.P. 1972. Response of gram varieties to inoculation and Nitrogen applicat or. Reports of the Agronomic Experiments on Rabi Pulses at Pantnagar during 1971-72. All India Coordinated Research Project on Pulses. Proceedings of the 8th Workshop: 196-197.

Saxena, M.C., Yadav, D.C., and Singh, N.P. 1971 Response of gram varieties to inoculation and Nitrogen. G.B. Pant University of Agriculture and Technology. Annual Report 153.

Seth, G.R., and Abraham, T.P. 1965. Crop response to fertilizers and their economics. Fertilizer News 10(12) 31-40.

Sharma, B.M., Yadav, J.S.P. 1976 Availability of phosphorus to gram as influenced by phosphate fertilization and irrigation regime. Indian Journal of Agri. Sciences 46(5): 205-210.

Sharma, D.C., and Shekhawat, G.S. 1972. Effect of Nitrogen, Phosphorus and Potash on gram varieties. Rajasthan Journal of Agr. Sciences 3(1): 7-10.

Sharma, K.N., Brar, J.S., Kapur, M.L., Meelu, O.P., and Rana, D.S. 1978 Potassium soil test values and responses of wheat, bajra and gram to fertilizer. Indian Journal of Agron. 23(1): 10-13.

Sharma, P.P., Singh, P., and Singh, P.P 1975. Response of Nitrogen and Phosphorus in relation to method of application, on the yield of gram (Cicer arietinum) JNKVV Research Journal 9 (1 and 2):21-23

Singh, B., and Srivastawa, S.K. 1978. Studies on the effect of micro-nutrient anions on the yield of gram. The Madras Agri. Journal, 65(3): 159-163.

Singh D., Leelavathi, C.P., and Bapat, S.R. 1975. A study of average output per unit application of fertilizers on farmer's field under dry farming conditions. Agricultural Situation in India 30(4) 237-240.

Singh, D.V., Chauhan, R.P.S., Singh, K., and Pal, B. 1978. Nitrogen and Phosphorus needs of gram (Cicer arietinum) along with bacterial fertilization. The Madras Agricultural Journal 65(6) 363-367.

Singh, Kalyan. 1969. Response of four bengal gram varieties to different fertilizer treatments. Unpublished M.Sc. (Agri.) thesis. Division of Agronomy, IARI:New Delhi.

Singh, Kanwar, J.S., and Katyal, S.K. 1966. Effect of mixed cropping of wheat and gram with varying levels of nitrogen and phosphorus on yield. Journal of Research, Ludhiana 3(4). 364-367.

Singh, Kanwar, Tripathi, H.P., and Raheja, H.R. 1972. Response of gram to Nitrogenous and Phosphatic fertilization under different crop rotations. Journal of Research, H.A.U. 2(1):19-24.

Singh, R.G. 1971. Response of gram (Cicer arietinum L.) to the application of Nitrogen and Phosphate. Indian Journal of Agricultural Sciences 41(2): 101-106.

Singh, R.K., and Agarwal, M.C. 1965. Effect of preparatory cultivation and N and P fertilization on gram (Cicer arietinum L.). The Balwant Vidyapeeth J. Agriculture and Scientific Research 7(1 & 2): 24-31.

Singh, R.N. 1976. To study the effect of agronomic management on growth and yield of gram varieties JG. 221 (Cicer arietinum), unpublished M.Sc. (Agri.) thesis. Department of Agronomy. Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur. Thesis Abstract 2(2): 92.

Singh, R.P. 1975. Economics of fertilizers under dryland conditions, Indian Journal of Agron. 20(2): 140-146.

Singh, R.P., and Singh, B. 1975. Studies on the levels and timings of Phosphorus application in rice and its residual effect of succeeding crop of Bengal gram. Journal of Scientific Research Banaras Hindu University 26(1): 55-60.

Singh, R.S. 1970. Effect of number of cultivation and increasing levels of N and P on yield and quality of gram (Cicer arietinum L.). Madras Agri. Journal 57(5): 267-270.

Singh Surinder. 1973. Study on the effect of Zinc and Sulphur on the yield potential of gram variety G-130. Agronomic Investigations on rabi pulses at H.A.U. Hissar during 1972-73. All India Coordinated Research Project on Pulses. Proceedings of the 10th Workshop:144.

Singh, Surinder. 1973. Effect of inoculation and fertilizer on the performance of gram variety G-130. Agronomic Investigations on Rabi pulses at H.A.U. Hissar during 1972-73. All India Coordinated Research Project on Pulses. Proceedings of the 10th Workshop: 148-149.

Singh, U.B., Tomer, S.P., and Jain, M.K. 1971. Effect of spray fertilization of Phosphorus in gram. Ann Arid Zone 10 (2&3): 199-202.

Sinha, M.N. 1971. Effect of doses and methods of Phosphorus placement on growth, yield and uptake of phosphorus by gram (Cicer arietinum L.) under irrigated conditions. Indian Journal of Agron. 16(1): 60-63.

Sinha, M.N. 1972. Effect of doses and methods of Phosphorus placement on growth, yield and uptake of Phosphorus by gram (Cicer arietinum L.) under rainfed conditions. Indian Journal of Agron. 17(1) 1-4.

Sinha, R.N., and Roy, R.N. 1965. Effect of different tilth, levels of Nitrogen and methods of Phosphate placement on the growth and yield of gram. Proc. Bihar Academy of Agri. Sciences 14: 68-76.

Sivarama Raju, K. 1974. Fertility-cum-inoculation trial. Results of the Coordinated trials on pulses at Rajendranagar, Kharif ICAR. 124.

Sivarama Raju, K., and Samuel, A.V. 1976 Response of gram (Cicer arietinum L.) to different rhizobial noculants. Madras Agri. Journal 63(11&12): 582-586.

Som, D., Sinha, N.B., and Nandi, P. 1971. Field trial experiment with gram (Cicer arietinum) seed inoculation with rhizobium and maintenance of soil fertility. All India Coordinated Research Project on Pulses. Proceedings of the 5th Workshop: 100-101.

Srivastava, O.P., and Pathak, A.N. 1970. Utilization of fertilizer phosphorus by paddy and gram crops in rotation. Symposium on Fertilizer. Bulletin B. Indian Society of Soil Science, New Delhi: 155-159.

Srivastava, S.P., and Singh, A.P. 1975. Phosphorus fertilization in gram under dryland conditions. Sci cult. 41(11): 527-528.

Subramanian, A., Michael Raj, S., and Venkatachalam, C 1974. A note on effect of graded doses of Phosphate and spacing on the yield of Bengal gram. Madras Agri. Journal 61(9): 791-792.

Tiwari, A.S., Laxman Singh and Mishra, P.K 1977. Response of Bengal gram (Cicer arietinum L.) genotypes to fertility levels Current Research 6(1) 16-17.

Tiwari, B.P., and Bisen, C.R. 1967 Economics of 'Birra' (mixed) sowing of wheat and gram with and without fertilizer under Havel (Bunded) conditions in Madhya Pradesh, JNKVV Research Journal 1(1): 17-23.

Wamanan, P.P., and Das, J.K. 1965 Fertilizer studies on chickpea (Cicer arietinum L.) in Assam. Journal of Assam Sci. Soc. 8: 45-50.

Wamanan, P.P., and Mal, P.N. 1968. Fertilizer application and placement in chickpea. Fertilizer News 13(2): 39-42.

Appendix Table 1. Response of Chickpea to fertilizers under rainfed conditions[a]

Location	Soil	Year	Variety	Yield over control	Average response Kg/Kg N[b]	Average net return Rs/Rs N
Bhatinda	Calcareous sierozome	1974-75	C.235	-77	-5.1	-3.01
		1975-76	C.235	94	4.7	0.84
Hissar	"	1977-78	C.214	193	9.7	2.78
Alwar	Alluvial	1975-76	RS-10	466	23.3	8.13
		1977-78	RS-10	1096	54.8	20.5
Ferozepur	"	1977-78	C.214	343	17.1	5.7
Ajmer	Red and yellow	1975-78	RS-10	238	11.9	3.66
Hazaribagh	"	1977-78	H.208	600	30.0	10.76
Bharatpur	"	1977-79	RS-10	941	47.1	17.46
Keonjhar	"	1976-77	Radhey	248	12.4	3.86
Indore	Medium Black	1975-76	Ujjain-29	116	5.8	1.27
Amravathi	"	1977-78	Chaffa-30	200	10.0	2.92
Hamirpur	Red Sandy	1977-78	T-3	283	14.2	4.56
Chickmagalur	"	1977-78	A-1	361	18.1	6.09
Medak	Red and laterite	1977-78	TG.482	366	18.3	6.17
Kangra	"	1977-78	C.235	108	5.4	1.12

a Source: Derived from Kulkarni (1980). These results were not included in the main analysis because of the recent publication of the article.

b Except for the first experiment which had 15 kg N/ha all others had 20 kg N/ha applied.