Maximization of yield in relation to the response of dwarf varieties of wheat and hybrids of maize, jowar and bajra to nitrogen

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The High Yielding Varieties Programme envisages the intensive cultivation of 32.5 million acres, using fertilizer-responsive varieties of hybrids of rice, wheat, ~~hybrid~~ maize, jowar and bajra in 12.5, 8, 4, 4 and 4 million acres respectively. The recommended doses of nitrogen for these crops are 100, 100, 80, 80 and 40 lb. N per acre or 112, 112, 90, 90 and 45 Kg. N per hectare. A supply of 1.29 million tonnes of N, in addition to suitable quantities of P and K, has been earmarked for the programme with an expectation of 25.5 million tonnes of additional food-grains.

An analysis of the results on the response to nitrogen of dwarf wheat and hybrids of maize, jowar and bajra obtained in co-ordinated trials carried out during 1965 and 1966 with the participation of the Indian Agricultural Research Institute and State Research Institutions conducted by Drs. P.N. Saxena, A.S. Sirohi, B.R. Murty and V.S. Shah of I.A.R.I. reveals the following trends:

A. Wheat

(1) Data - The response to nitrogen for the Indian varieties of wheat were available from fertilizer experiments carried out at the I.A.R.I. from 1946-47 onwards. Data for the Mexican varieties, Sonora 63, Sonora 64 and Lerma Rojo, along with the

Punjab variety C.306, were available from co-ordinated experiments during 1964-65 and 1965-66, carried out at 41 centres in the country with doses of nitrogen ranging from 0 to 200 lb. N/acre.

(2) The response function for N.P. varieties of wheat, based on experiments at the I.A.R.I., was found to be quite similar to that obtained by the I.A.R.I., for the indigenous varieties of wheat based on trials in farmer's fields.

(3) In the co-ordinated trials during 1964-65, N.P.876 was found to be slightly superior to N.P.887 but showed lower response than the Mexican varieties.

(4) The profit maximizing (optimal) levels of nitrogen showed wide variation from State to State and variety to variety.

(5) The dwarf varieties Sonora 63, Sonora 64, Lerma Rojo and the Indian variety C.306 showed the highest response in Zone 1 (Punjab, U.P., Delhi and Rajasthan) followed by Zone 3 (Bihar and West Bengal). For all varieties, the average responses in other zones were much lower.

(6) In Zone 1 and for the average over all zones, the highest yields are given by Lerma Rojo, followed by Sonora 64, Sonora 63 and C.306.

(7) At current prices and using the average response function over all Zones, the optimal dose of nitrogen for the three dwarf varieties was found to lie between 120-125 Kg. N per hectare. The corresponding values for C.306 and for the indigenous varieties in cultivators' fields were 91 and 51 Kg. N per hectare respectively.

(8) In the Agronomy trials during 1965-66, the dwarf varieties Sonora 64 and Lerma Rojo showed significantly higher response with 6 instead of 4 irrigations

at two centres. C.306 suffered due to lodging at one of these centres. The interaction of irrigation with nitrogen levels was, however, not significant.

(9) Among all the varieties studied, Sonora 64 gave the highest response to N in terms of additional production over no nitrogen application.

(10) The National wheat demonstrations in various States of India gave ample testimony to the high yield potential of the dwarf wheats. An yield of 168 q/ha was obtained at Delhi with S.227 in a 1-hectare plot during rabi 1965-66.

(11) An allotment of 0.36 million tonnes of N, at the rate of 112 Kg N/ha over an area of 3.2 million hectares has been made in the programme for the dwarf wheats. This will account for an additional production due to nitrogen of 4.7 million tonnes of wheat grain. A more efficient utilization of the same supply of nitrogen can, however, be made by reallocating it between the Mexican and Indian varieties of wheat, over the entire irrigated area of 6,4 million hectares, at the rate of about 80 and 32 Kg. N per hectare for the dwarf and tall wheats respectively. This will account for an additional production due to nitrogen of 5.6 million tonnes and will also ensure varietal diversity, essential for avoiding the outbreak of disease epidemics.

(12) The above suggestion is based on the response to nitrogen in Indian varieties observed in trials conducted in cultivators' fields. It is not materially altered even on using the response function for the Indian variety C.306, as the output maximising doses now become 75 and 37 Kg. N per hectare.

(13) The estimate of additional production due to nitrogen based on the present data, comes to about 1.2 tonnes per hectare when an optimal allocation of the limited N supply is made between the dwarf and Indian varieties. The figure of a tonne per acre additional production, over existing varieties and fertilizer levels expected in the programme appears to be difficult of attainment, except under excellent management conditions.

(14) The additional net returns due to nitrogen application are the highest with Sonora 64. These are about twice as large as those obtainable with Indian varieties at their respective economic optimum levels.

(15) Due to the import of 18,000 tonnes of seeds from Mexico during 1966 seeds of the dwarf varieties will not be a limiting factor in extending their cultivation to the entire irrigated wheat area from next year. The quantity of nitrogenous fertilizers allocated to wheat in the programme will, under this situation, be extremely inadequate to exploit their full genetic potential.

B. Maize

(1) The response to nitrogen in experiments under the All-India Co-ordinated Maize Improvement Scheme, conducted at various locations in the country during 1961 to 1963, making up a total of 17 trials was studied. The levels of nitrogen tried were 0, 45, 90, 135, 180 Kg. N. per hectare and the hybrids included in the trials were U.S. 13, Ganga 101 and Deccan Hybrid Makka.

(2) The maize crop in general and hybrid maize in particular gave a very high response to nitrogen fertilization, especially in Zone 1 (Foot-hills of

Himalayas) and Zone IV (Peninsular India). At 45 Kg. N/ha, the response in the hybrids varied from 15 to 37 Kg of grain per Kg of nitrogen. Responses in the hybrids were higher than those in the locals at all levels of fertilizer application.

(3) The economic optimum levels, in different zones, ranged from about 150 to 250 kg N/ha for the hybrids and from about 125 to 170 Kg N/ha for the local varieties. The corresponding doses, based on the average over all zones, were about 200 Kg N/ha for the hybrid and 140 Kg N/ha for the local vareities.

(4) The net profits due to nitrogen, applied at the optimal rates, ranged from Rs.600 to1100 per hectare in the hybrid and Rs.300 to 800 in the local varieties. The hybrids thus responded profitably to a level of nitrogen about 50% higher than the local varieties, bringing a net return from investment in fertilizer which is about 50 to 100 per cent higher.

(5) At their respective optimum levels of nitrogen application, the hybrids gave about 50% higher yield than the local varieties in all zones. This result is also supported by the nation wide hybrid-maize demonstrations during rabi 1963-64 and kharif 1964-65.

(6) Application of 90 Kg N/ha to hybrid maize, as envisaged under the official plan, appears to be too conservative, as it would cut down the profits to nearly 70% of the value obtainable under optimal conditions.

(7) Using the average response function and under optimal nitrogen application, the expected yields for the local and hybrid varieties are about 35 and 51 quintals per hectare leading to an additional production of about 16 q/ha of maize grain.

(8) A limited supply of chemical fertilizers could be considered as the most important factor limiting the yield potential of the maize hybrids, the profits of the farmers and the rate of growth in maize production in the country.

C. Sorghum (Jowar)

(1) The response to nitrogen of hybrid jowar CSH-1, in trials conducted at 8 locations during kharif 1965-66, have been analysed. The levels of nitrogen applied ranged from 0 to 200 Kg N/ha.

(2) The yield and response to fertilizer in the hybrid as compared to the local varieties is variable depending on the region of adaptation of the hybrid which is earlier by 10 to 100 days than the locals.

(3) In the six centres of adaptation, the responses of the hybrid were much higher than the local. On an average, the linear response in the hybrid was about 2.5 times larger than the local. The highest yield of about 50 quintals per hectare, using 200 Kg N/ ha, was obtained with the hybrid at Siruguppa (Mysore).

(4) In the two centres of poor adaptation, poor stands of the hybrid and longer duration of maturity of the locals appear to be responsible for the failure of the hybrids. It has not been possible to successfully compare these hybrids with the locals in the long duration tracts of Maharashtra and Madhya Pradesh.

(5) The response in Kg. grain per kg N applied at the rate of 200 Kg N/ha, was 7.8 Kg in the hybrid was compared to 5.0 in the locals in the areas of adaptation. The responses were much lower in the two centres of poor adaptation.

(6) With three plant population levels at Dharwar centre, the responses to nitrogen in the hybrid were higher than the local in all cases. The highest rate of response as well as the best yield were obtained with a plant population level of 136,000 plants/ha or 6" between plants.

(7) On an average, the response to the hybrid in the interval 50-100 Kg N/ha was higher than that of local in the interval 0-50 Kg N/ha.

(8) The economic optimum nitrogen dose for the hybrid, in the adapted region, was found to be 135 Kg.N/ha. It corresponds to an additional grain production due to nitrogen of about 15.2 q/ha. The dose of 90 Kg N/ha envisaged in the programme appears to be quite conservative as it would reduce the production (and profits) of the individual farmers by about 20%.

D. Pearl Millet (Bajra)

(1) The response to nitrogen for the hybrid bajra H.B.1, in trials conducted at 7 locations during kharif 1965-66, was examined. The levels of nitrogen ranged from 0 to 160 Kg N per hectare.

(2) The responses to nitrogen in the hybrid were higher than the local except at two locations. On an average, the linear response in the hybrid was about 1.7 times larger than the local.

(3) The highest yield of about 60 q/ha with the hybrid was obtained at Fatehabad (U.P.).

(4) The increase in grain output per Kg of nitrogen, applied at the rate of 160 Kg N/ha, was 8.4 Kg. in the hybrid as compared to 4.3 in the locals.

(5) On an average, the response of the hybrid in the intervals 40-80 Kg N/ha was higher than that of the local in the interval 0-40 Kg N/ha.

(6) The economic optimum nitrogen dose for the hybrid was found to be about 160 Kg N/ha. This corresponds to an additional grain production due to nitrogen of about 13.3 q/ha. The dose of 45 Kg/ha envisaged in the official programme for this crop appears to be very low and would reduce the response (and profits) due to nitrogen by about 60 per cent.

CONCLUSIONS

The foregoing survey suggests that to realise the full yield potential of the hybrids of maize, jowar and bajra as well as of dwarf wheats, fertilizer doses much higher than what is possible with the available quantities are needed. So long as the total availability of fertilizer remains limited, it is important that different doses are recommended for different areas, based on the yield possibilities. For example, Punjab, Haryana and parts of U.P. and Rajasthan are climatically more favourable for higher wheat yield than Bihar or Maharashtra. A more scientifically based allocation pattern is hence necessary to maximize output from the existing fertilizer resource. Also, it is essential that in crops like wheat, suitable allocations are made for the dwarf and tall varieties, so as to get the best out of both and to maintain a degree of varietal diversity necessary for avoiding the large scale outbreak of any particular disease. Finally, the great role that management factors such as time of application of water and plant density play in determining the fertilizer response function needs to be understood and exploited. Even small differences in management practices make a large difference in yield in the case of high-yielding varieties. The effect of irrigation time on wheat yield (the fertilizer dose and all other management factors being the same) is shown in Table 1. It is very important that

serious attention is paid to the dissemination of knowledge concerning the qualitative aspects of input use so that, on the one hand, the farmer can get the maximum return from his investment on inputs and on the other, the country can reap the maximum harvest possible with the existing resources of fertilizer and water.

Critical stage of irrigation for dwarf wheat Sonora 64

Time of irrigation

Treatment	0 - 60 days		60 - 90 days		90 - 120 days		Total No. of irrigations	Grain yield Q/ha.
	Pre to late tillering stage		Jointing to flowering Stage		Soft to hard dough stage			
1	2		3		4		5	6
1	1*	1	1	1	1	1	6	51.4
2.	1	1	x	1	1	x	4	51.3
3.	1	1	x	x	1	1	4	52.3
4.	x	1	x	1	1	1	4	44.0
5.	x	1	1	1	1	x	4	45.2
6.	x	1	x	1	1	x	3	42.3

~~666~~

SEm ± 2.87
C.D at 5% 5.87

* First irrigation falls at the time of crown root initiation stage.

1 Indicates irrigation given.

x Indicates irrigation not given.

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~~A RESUME OF THE DATA ON THE~~ RESPONSE OF DWARF VARIETIES OF WHEAT AND HYBRIDS OF MAIZE, JOWAR AND BAJRA TO NITROGEN.

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An analysis of
The results on the responses to nitrogen of dwarf wheat and hybrids of maize, jowar and bajra, ~~based on the results of~~ obtained in co-ordinated trials carried out during 1965 and 1966 with the participation of the Indian Agricultural Research Institute and State Research Institutes ~~have been reviewed in the earlier papers and a resume of the important results is given below:~~ conducted by Drs P.N. Saxena, A.S. Sirohi, B.R. Murty and V.S. Shah of IARI reveals the following trends

A. WHEAT

(1) Data - The response to nitrogen for the Indian varieties of wheat were available from fertilizer experiments carried out at the I.A.R.I. from 1946-47 onwards. Data for the Mexican varieties, Sonora 63, Sonora 64 and Lerma Rojo, along with the Punjab variety C.306, were available from co-ordinated experiments during 1964-65 and 1965-66, carried out at 41 centres in the country with doses of nitrogen ranging from 0 to 200 lb. N/acre.

(2) The response function for N.P. varieties of wheat, based on experiments at the I.A.R.I., was found to be quite similar to that obtained by the I.A.R.I., for the indigenous varieties of wheat based on trials in farmer's fields.

(3) In the co-ordinated trials during 1964-65, N.P.876 was found to be slightly superior to N.P.887 but showed lower response than the Mexican varieties.

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Contd...2.

(5) The dwarf varieties Sonora 63, Sonora 64, Lerma Rojo and the Indian variety C.306 showed the highest response in Zone 1 (Punjab, U.P., Delhi and Rajsthan) followed by Zone 3 (Bihar and West Bengal). For ~~any variety~~ all varieties, the average responses in other zones were much lower.

(6) In Zone 1 and for the average over all Zones, the highest yields are given by Lerma Rojo, followed by Sonora 64, Sonora 63 and C.306.

(7) At current prices and using the average response function over all Zones, the optimal dose of nitrogen for the three dwarf varieties was found to lie between 120-125 kg. N per hectare. The corresponding values for C.306 and for the indigenous varieties in cultivators' fields were 91 and 51 kg. N per hectare respectively.

(8) In the Agronomy trials during 1965-66, the dwarf varieties Sonora 64 and Lerma Rojo showed significantly higher response with 6 instead of 4 irrigations at two centres. C. 306 suffered due to lodging at one of these centres. The interaction of irrigation with nitrogen levels was, however, not significant.

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hectares, at the rate of about 80 and 32 kg. N per hectare for the dwarf and tall wheats respectively. This will account for an additional production due to nitrogen of 5.6 million tonnes and will also ensure varietal diversity, essential for avoiding the outbreak of disease epidemics.

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B. MAIZE

(1) The responses to nitrogen ~~from~~ in experiments under the All-India Co-ordinated Maize Improvement Scheme, conducted ~~for one to three years~~ at various locations in the country during 1961 to 1963, making up a total of 17 trials, ~~have been summarised.~~ was studied. The levels of nitrogen

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tried were 0, 45, 90, 135, 180 kg. N per hectare and the hybrids included in the trials were U.S.13, Ganga 101 and Deccan Hybrid Makka.

(2) The maize crop in general and hybrid maize inparticular gave a very high response to nitrogen fertilization, especially in Zone 1 (Foot-hills of Himalayas) and Zone IV (Peninsular India ~~Southern zone~~). At 45 kg. N/ha, the response in the hybrids varied from 15 to 37 kg of grain per kg of nitrogen. Responses in the hybrids were higher than these in the locals at all levels of fertilizer application.

(3) The economic optimum levels, in different zones, ranged from about 150 to 250 kg N/ha for the hybrids and from about 125 to 170 kg N/ha for the local varieties. The corresponding doses, based on the average over all zones, were about 200 kg N/ha for the hybrid and 140 kg N/ha for the local varieties.

(4) The net profits due to nitrogen, applied at the optimal rates, ranged from Rs.600 to 1100 per hectare in the hybrid and Rs.300 to 800 in the local varieties. The hybrids thus responded profitably to a level of nitrogen about 50% higher than the local varieties, bringing a net return from investment in fertilizer which is about 50 to 100 per cent higher.

(5) At their respective optimum levels of nitrogen application, the hybrids gave about 50% higher yield than the local varieties in all zones. This result is also supported by the nationwide hybrid-maize demonstrations during Rabi 1963-64 and kharif 1964-65.

(6) Application of 90 kg N/ha to hybrid maize, as envisaged under the official plan, appears to be too conservative, as it would cut down the profits to nearly 70% of the value obtainable under optimal conditions.

(7) Using the average response function and under optimal nitrogen application, the expected yields for the local and hybrid varieties are about 35 and 51 quintals per hectare leading to an additional production of about 16 q/ha of maize grain.

Contd....5.

(8) A limited supply of chemical fertilizers could be considered as the most important factor limiting the yield potential of the maize hybrids, the profits of the farmers and the rate of growth in maize production in the country.

C. SORGHUM (Jowar)

(1) The response to nitrogen ~~for~~ of hybrid Jowar CSH-1, in trials conducted at 8 locations during kharif 1965-66, have been analysed. The levels of nitrogen applied ranged from 0 to 200 kg N/ha.

(2) The yield and response to fertilizer in the hybrid as compared to the local varieties is variable depending on the region of adaptation of the hybrid which is earlier by 10 to 100 days than the locals.

(3) In the six centres of adaptation, the responses of the hybrid were much higher than the local. On an average, ~~over these centres~~, the linear response in the hybrid was about 2.5 times larger than the local. The highest yield of about 50 quintals per hectare, using 200 kg N/ha, was obtained with the hybrid at Siruguppa (Mysore).

(4) In the two centres of poor adaptation, poor stands of the hybrid and longer duration of maturity of the locals appear to be responsible for the failure of the hybrids. It has not been possible to successfully compare these hybrids with the locals in the long duration tracts of Maharashtra and Madhya Pradesh.

(5) The response in kg. grain per kg N, applied at the rate of 200 kg N/ha, was 7.8 kg in the hybrid as compared to 5.0 in the locals in the areas of adaptation. The responses were much lower in the two centres of poor adaptation.

(6) With three plant population levels at Dharwar centre, the responses to nitrogen in the hybrid were higher than the local in all cases. The highest rate of response as well as the best yield were obtained with a plant population level of 136,000 plants/ha or 6" between plants.

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(7) On an average, the response to the hybrid in the interval 50-100 kg N/ha was higher than that of local in the interval 0-50 kg N/ha.

(8) The economic optimum nitrogen dose for the hybrid, in the adapted region, was found to be 135 kg N/ha. It corresponds to an additional grain production due to nitrogen of about 15.2 q/ha. The dose of 90 kg N/ha envisaged in the programme appears to be quite conservative as it would reduce the production (and profits) of the individual farmers by about 20%.

D. PEARL MILLET (Bajra)

(1) The responses to nitrogen for the hybrid bajra H.B.1, in trials conducted at 7 locations during kharif 1965-66, ~~have been~~ was examined. The levels of nitrogen ranged from 0 to 160 kg N per hectare.

(2) The responses to nitrogen in the hybrid were higher than the local except at two locations. On an average, the linear response in the hybrid was about 1.7 times larger than the local.

(3) The highest yield of about 60 q/ha with the hybrid was obtained at Fatehabad (U.P.)

(4) The increase in grain output per kg of nitrogen, applied at the rate of 160 kg N/ha, was 8.4 kg in the hybrid as compared to 4.3 in the locals.

(5) On an average, the response of the hybrid in the intervals 40-80 kg N/ha was higher than that of the local in the interval 0-40 kg N/ha.

(6) The economic optimum nitrogen dose for the hybrid was found to be about 160 kg N/ha. This corresponds to an additional grain production due to nitrogen of about 13.3 q/ha. The dose of 45 kg N/ha envisaged in the optimal programme for this crop appears to be very low and would reduce the response (and profits) due to nitrogen by about 60 per cent.

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CONCLUSIONS

The foregoing survey suggests that to realise the full yield potential of the hybrids of maize, jowar and bajra as well as of dwarf wheats, fertilizer doses much higher than what is possible with the available quantities are needed. So long as the total availability of fertilizer remains limited, it is important that different doses are recommended for different areas, based on the yield possibilities. For example, Punjab and parts of U.P. and Rajasthan are climatically more favourable for higher wheat yield than Bihar or Maharashtra. A more scientifically based allocation pattern is hence necessary to maximize output from the existing fertilizer resource. Also, it is essential that in crops like wheat, suitable allocations are made for the dwarf and tall varieties, so as to get the best out of both and to maintain a degree of varietal diversity necessary for avoiding the large scale outbreak of any particular disease. Finally the great role that management factors such as time of application of water and plant density play in determining the fertilizer response function needs to be understood and exploited. Even small differences in management practices make a large difference in ~~the ultima~~ yield in the case of high-yielding varieties. The effect of irrigation time on yield (the fertilizer dose and all other management factors being the same) is shown in Table 1. It is very important that serious attention is paid to the dissemination of

knowledge concerning the qualitative aspects of input use so that, on the one hand, the farmer can get the maximum return from his investment on inputs and on the other, the country can reap the maximum harvest possible with the existing resources of fertilizer and water.