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ECONOMISING NITROGEN USE FOR PEARL MILLET IN THE INDIAN ARID ZONE

N.L. JOSHI AND JAGDEESH C. KALLA

Central Arid Zone Research Institute, Jodhpur - 342 003

ABSTRACT

Economic analysis of the response of six pearl millet varieties to nitrogen application was done to determine minimum fertilizer doses which can economically substitute optimal nitrogen doses. High magnitudes of coefficient of determination (R^2) were obtained for CM 46, PHB 12 and local cultivar. The varieties BJ 104 and BD 111 registered medium degrees of R^2. The nitrogen alone could not generate more than 18% R^2 in WCC 75. The optimum nitrogen level for local, BJ 104, BD 111, CM 46, PHB 12 and WCC 75 was 63.95, 65.98, 74.37, 84.19, 82.47 and 181.34 kg/ha, respectively. The highest nitrogen utilization efficiency for maximised and optimised production was 17.86 and 20.52 kg grain/kg N with BJ 104. The 'pragmatic' N levels revealed possibility of maximum nitrogen curtailment (62 kg/ha) from optimum nitrogen level in WCC 75 while about 24 kg N/ha curtailment was possible for CM 46 and PHB 12. The varieties BJ 104 and BD 111 were highly sensitive to N curtailments with a reduction of 16 and 19 kg N/ha, respectively from the optimum dose.

INTRODUCTION

Pearl millet is one of the most important elements of agrarian enterprise - mix in the Indian arid zone. In western Rajasthan, which accounts for nearly 62% of the Indian arid zone, pearl millet occupies 80% of the total cropped area. The average productivity of this rainfed millet has remained static. More than 90% of the area under pearl millet has erratic and low rainfall. Despite availability of new genotypes, more than 85% of the cropped area is covered by local varieties which are poor in response to inputs, specifically fertilizers and have high susceptibility to diseases. The combination of production constraints and climatic uncertainties lead the farmer to a basic reluctance for application of fertilizer in the production of pearl millet.

The recommendations to use physical optima of fertilizers for optimum yield of pearl millet (Pal and Kaushik, 1973; Malik and Sharma, 1979; Gautam *et al.*, 1981 and Joshi, 1984) or economic optima pre-suppose no constraint on availability of fertilizers. In view of shortages of fertilizer nitrogen, the need of its economised use without impairing the prospects of productivity of a crop like pearl millet assumes special significance in Indian arid zone. In the present study an attempt has been made

to trace out the comparative sensitivity of six pearl millet varieties for economising use of fertilizer nitrogen (N).

MATERIAL AND METHODS

The economic analyses were based on the data derived from field trials conducted at the Central Arid Zone Research Institute, Jodhpur, during 1979 to 1983. The treatments consisted of combination of six pearl millet varieties (Local, BJ 104, BD 111, CM 46, PHB 12 and WCC 75) and five levels of nitrogen (0, 30, 60, 90 and 120 kg N/ha) in split plot design with four replications. The linear, quadratic and square root functions were fitted to the yield data. From amongst these functions, one satisfying the best fit criterion based on examination of R^2 (coefficient of determination) and the significance of partial regression coefficients, was chosen. The yield of two high R^2 years was pooled to generate representative fertilizer response functions. From these equations, the 'maximum' and 'optimum' quantities of nitrogen were determined by equating partial derivatives of yield with respect to nitrogen to zero and to input-output price ratio for optimality computation. These were employed to generate 'maximum' (Y_{max}) and 'optimum' (Y_{opt}) yields for varieties under consideration. The input-output prices used were Rs 4.29/kg of N and Rs 1.58/kg of pearl millet grain. From maximum doses the nitrogen curtailing schedules were worked out where without impairing the production potential, the quantities of nitrogen were allowed to diminish at 10 kg reduction interval. The consequent yields and fertilizer doses were respectively, converted into gross pay-off and cost items. The gross pay-off was transformed into net pay-off by subtracting cost of fertilizer at each successive step. From these steps minimum tolerable limit of fertilizer nitrogen use or a 'pragmatum' was located. Finally, some policy implications of fertilizer use of pear millet were evolved by drawing the inferences of yield-nitrogen application relationship.

RESULTS AND DISCUSSION

Nitrogen response functions:

From among the three alternative forms, the nitrogen response was more adequately described by Quadratic response surfaces. The results of the 'best-fit' specifications are set out in Table 1. The results revealed that nitrogen in the linear and non-linear effects registered accepted signs in conformity with the logic of diminishing marginal returns. The magnitude of intercept in response functions for all the varieties revealed that additional specification of other variables could result into better and unbiased estimates of the productivity coefficients. Despite the singularity of factor involved, the high magnitudes of R^2 were obtained for CM 46, PHB 12 and local cultivar. The varieties BJ 104 and BD 111 registered medium degrees of R^2 (Table 1). The nitrogen alone could not generate more than 18% R^2 in WCC 75 indicating that nitrogen, in conjuction with other inputs, may generate a better fit response surface. In terms

Table 1. Nitrogen response functions for pearl millet varieties

Varieties‡	Intercept	N	N^2	R^2
Local	450.86	11.14***	−0.066***	0.5745
		(1.983)	(0.015)	
BJ 104	617.27	19.59***	−0.128**	0.3799
		(4.608)	(0.037)	
BD 111	450.41	14.30***	−0.078**	0.4543
		(3.586)	(0.028)	
CM 46	465.99	13.98***	-0.067**	0.6807
		(2.536)	(0.020)	
PHB 12	544.62	14.41***	−0.071**	0.5564
		(3.281)	(0.026)	
WCC 75	1312.58	11.04	−0.023	0.1755
		(11.253)	(0.090)	

‡ For Local, BJ 104, BD 111, CM 46 and PHB 12 the results were generated from data of 1979 and 1980 while for WCC 75 the data of 1982 nnd 1983 were used.
Figures in parentheses indicate standard errors of the respective coefficients.
, * : Significant at 1 and 0.1% levels of probability, respectively.

of minor productivity BJ 104, PHB 12 and BD 111 registered high magnitude signifying higher degree of nitrogen response.

Fertilizer-yield relationship:

The maximum, optimum and average quantities of nitrogen and consequent yields of six pearl millet varieties under consideration are presented in Table 2. The variety WCC 75 was the highest user of nitrogen where 2637 kg/ha yield was realised with the application of 240 kg N/ha. The lowest nitrogen utilization by BJ 104 at about 76 kg/ha resulted in production of 1366 kg grain/ha (Table 2). The highest nitrogen utilization efficiency for maximised production (17.86 kg grain/ha N) was recorded with BJ 104. Similarly for optimum dose of nitrogen, barring local variety (64 kg N/ha), BJ 104 under the restricted optima generated about 1353 kg grain at 66 kg of optimum nitrogen utilization leading to about 21 kg grain yield per kg nitrogen applied at optimum level. On an average the highest efficiency with a constant of 60 kg nitrogen application was, however, discernible for WCC 75 (31 kg grain/kg N).

Economising nitrogen use :

To work out nitrogen curtailing schedule without impairing the production potential, the quantities of nitrogen were allowed to diminish at 10 kg reduction interval. The cost reduction and consequent net pay-off incidental to the reduction in the quantities of fertilizer were iterated till the loss in net pay-off was equivalent to the gains in the cost of reduction of fertilizer. This was termed as 'pragmatic' level of nitrogen. The results are set out in Table 3. Reduction in nitrogen utilization by

Table 2. Nitrogen—yield relationships for pearl millet varieties

Varieties	N_{max} (kg/ha)	Y_{max} (kg/ha)	Y/N_{max} (kg)	N_{opt} (kg/ha)	Y_{opt} (kg/ha)	Y/N_{opt} (kg)	Y (kg/ha)	N (kg/ha)	Y/N (kg)
Local	84.44	920.93	10.90	63.95	893.34	13.96	764.33	60	12.73
BJ 104	76.52	1366.82	17.86	65.98	1352.59	20.52	1102.90	60	18.63
BD 111	91.66	1105.82	12.06	74.37	1082.49	14.55	887.87	60	14.79
CM 46	104.33	1195.25	11.45	84.19	1168.07	13.87	942.50	60	15.71
PHB 12	101.47	1261.36	12.43	82.47	1250.12	15.15	1022.14	60	17.03
WCC 75	240.00	2637.38	10.98	181.34	2558.23	14.10	1851 25	60	30.85

Table 3. Schedule for economising nitrogen in pearl millet varieties

Varieties	Pragmatic nitrogen (kg/ha)	Gross pay-off (Rs)	Cost of nitrogen reduction (Rs)	Net pay-off (Rs)	Differential pay-off (Rs)	Value of differential nitrogen reduction of 10 kg unit (Rs)	Difference from optimum to pragmatum (kg N/ha)
Local	39.4	1243.96	169.02	1074.94	42.27	42.90	24 55
BJ 104	50.2	2019.43	215.35	1804.08	42.87	42.90	15.78
BD 111	55.0	1581.51	235.94	1345.56	43.49	42.90	19.37
CM 46	59.5	1675.75	255.25	1420.05	43.38	42.90	24.69
PHB 12	59.4	1817.07	254.82	1762.25	42 01	42.90	23.07
WCC 75	119.5	3639.39	512.65	3126.74	42.90	42.90	61.84

62 kg N/ha was registered for WCC 75. On an average CM 46 and PHB 12 registered curtailments resulting into saving of about 24 kg N/ha at net pay-off of Rs. 1400 and 1700/ha, respectively. Varieties BJ 104 and BD 111 registered saving of 16 and 19 kg N/ha, respectively. Thus varieties BJ 104 and BD 111 were highly sensitive to the curtailment in nitrogen doses. Further, since the variety WCC 75 initially has a very high nitrogen requirement, CM 46 and PHB 12 turn out to be more desirable from the point of view of nitrogen use. The reduction in nitrogen for these varieties in every 3 ha could be utilised for 1 ha additional area earlier receiving no nitrogen application at all. Thus the sagging effect of this curtailment would be taken care of by application of nitrogen for the pearl millet cultivation on other farms. This may assure more equitable distribution of an important input amongst larger number of farmers.

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