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THE EFFECTS OF INOCULATION AND PHOSPHATE FERTILIZER ADDITION ON THE PRODUCTIVITY OF LENTILS UNDER RAINFED CONDITIONS IN UPLAND BALUCHISTAN, PAKISTAN

by

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The Effects of Inoculation and Phosphate Fertilizer Addition on the Productivity of Lentils under Rainfed Conditions in Upland Baluchistan, Pakistan

by

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ABSTRACT

The experiment reported in this paper was conducted at Quetta in both the 1985/86 and 1986/87 cropping seasons and at Khuzdar, only in the 1986/87 season, to determine the effects of the addition of phosphate fertilizer and rhizobium inoculum to lentils (*Lens culinaris*) under arid rainfed conditions. A large response to inoculation was observed in both locations and seasons. In particular, this was observed to increase nodule number and root dry weight very substantially, and in turn, this accounted for a general increase of more than 50% in seed and straw production. Inoculation is therefore concluded to be a necessary input in food and forage legume germplasm evaluation nurseries in upland Baluchistan. In contrast, the effect of addition of 60 kg/ha of phosphate fertilizer did not appear to materially influence plant growth and productivity. It was additionally evident that the effects on crop growth of environmental variation in rainfall and air temperature considerably influenced the length of the active growth season of lentils and thus productivity.

Inoculation of lentils is concluded to be an agronomic intervention that has a potential profitability so large that rapid adoption and an increase in lentil hectarage in Baluchistan are likely once commercial supplies of inoculum are available.

INTRODUCTION

Lentil is the second most important grain legume crop in Pakistan. It is grown in winter over an area of 82,300 ha with an annual production of 29,900 metric tonnes (Bashir et al. 1986). Out of the four provinces of Pakistan, 70% of the cultivated area is in the Punjab while Baluchistan has presently the lowest hectarage (Anwar et al. 1986). Lentils are capable of growth in the poorer soils and more extreme climates of Pakistan, as are found and experienced in upland Baluchistan. However, the outlook for increased cultivation and productivity of lentils in Baluchistan has not in the past been favourable. Farmers view cropping under non-irrigated conditions to be a risky exercise in the arid uplands and have very little financial resources to invest in new technological agronomic innovations (Rees et al. 1988). As a result, research strategies which aim to ensure the maintenance of an acceptable soil nutrient status, without recourse to expensive inputs such as additions of nitrogen fertilizer, and which improve legume productivity substantially warrant active development.

Inadequate nitrogen nutrition appears to be one of the factors seriously limiting lentil productivity per unit area and the expansion of its hectarage and that of other food and forage legume crops in Baluchistan. The Arid Zone Research Institute has recently established a program of germplasm evaluation to determine whether food and forage legume crops can be successfully grown in the rainfed uplands of Baluchistan (ICARDA; 1987, 1988). At present, the mono-cropping of wheat or wheat in rotation with long, unproductive fallows are the present cropping practices under the traditional low input system of husbandry. The introduction of more legume crops may intensify agricultural production and at the very least reduce the risks of disease-induced total crop failure. Epiphytotic conditions of yellow rust in wheat have been experienced in Baluchistan with resultant severe crop losses at least twice in the last decade. The experiment was designed to give guidance on two issues relative to the introduction or intensification of legume cropping:

1. Are native soil rhizobial populations adequate to nodulate food and forage legume screening nurseries successfully?

2. Is rhizobial inoculation likely to be an economically sound innovation into the dryland cropping systems of upland Baluchistan?

MATERIALS AND METHODS

The experiment was first planted at the AZRI Farm, Quetta (altitude 1750m, latitude 300 14'N, longitude 670 2'E) in late December 1985 following the first rain of the winter season. Subsequently, it was repeated at the AZRI Farm and extended to an additional location Khuzdar (altitude 1100m, latitude 270 46'N, longitude 660 39'E) during the 1986/87 growing season. The planting date at Quetta during 1986/87 was 1 Nov 1986 and at Khuzdar 13 Oct 1986. Residual soil moisture from late summer rains allowed early crop establishment. Crop maturity occurred in early summer with little variation from location to location or year to year. The experiment was laid out in randomized complete blocks (two factor factorial) with a plot size of 5m x 1.5m. There were four treatment combinations with four replications. Each plot consisted of six rows with each row being 5m long and having a .25m row spacing. Phosphate fertilizer, as triple super phosphate, was incorporated with the seed at the time of sowing at the rate of 60 kg P2O5/ha. The experiment was planted with a single row drill. All observations were made from the central two rows of the plot to exclude border effects. A wide range of plant growth parameters were assessed and the number of nodules per plant and root dry weights were monitored periodically before crop maturity. Analysis of variance was conducted both separately and collectively to examine specific location or season effects and averaged over environments.

CLIMATIC CONDITIONS

The climatic conditions in Baluchistan are highly inconsistent. 200 mm of precipitation or less are expected in at least three years in ten (Keatinge and Rees, 1988). Furthermore, rainfall is often not well distributed throughout the year. Most of the rain occurs in the winter but occasionally a small but important summer monsoonal rain is experienced. Late rainfall in winter may delay the sowing of winter crops and subsequent crop emergence due to low air temperatures experienced at altitudes above 1000 m. In the 1985/86 season the first rains of the winter season came in the last week of December at Quetta. Dry conditions in April and May, coupled with dessicating winds, resulted in premature maturity and poor yields of lentils in 1985/86. While in the 1986/87 season, yields were good due to an early, well distributed and greater than average rainfall at Quetta and Khuzdar (Table 1).

Air temperature in upland Baluchistan is usually very low in winter and growth of lentil crops in the period late November to mid February is very slow. In both seasons, minimum air temperatures well below freezing were experienced (Table 1), but the local lentil landrace is well adapted to such conditions. High air temperatures in early summer, in the absence of rainfall, may become an important factor in hastening crop maturity as was experienced in the 1985/86 season in Quetta.

RESULTS AND DISCUSSION

The effect of inoculation was highly significant (P<0.1) and resulted in large increases in the number of nodules per plant (200%), root dry weight (70%), shoot dry weight (114%), seed yield (67%) and straw yield (52%) when compared to uninoculated treatments (Table 2-5).

The effect of phosphate was not significant and gave no increase in growth parameters, such as number of nodules per plant and straw yield, over the control treatment (Table 2, 5). Root dry weight may have been a minor exception (Table 3).

In the economic analysis only inoculation was considered as the biological effect of phosphate was shown to be insignificant. An increase in net revenue of Rs. 112 during the 1985/86 season and Rs. 2738 during the 1986/87 season were estimated for the trials at Quetta. Similarly, in the 1986/87 season at Khuzdar an increased net revenue of Rs. 2383 was obtained by inoculation (Table 6).

The importance of inoculation with rhizobia for lentil productivity is in concurrence with the work of Sekhon *et al*. (1986) and Sandhu (1984) who in other areas of the Sub-continent recorded 80-90% increases in seed yield in comparison to uninoculated lentils on a variety of soil types.

The clear response to inoculation in lentils in this experiment indicates the need to use inoculation routinely in AZRI's legume germplasm screening nurseries. This policy has been adopted in the 1987/88 season. The lack of native rhizobia in the soil or their inefficiency to promote active nodulation in lentils (Table 2) suggests that the use of inoculation could be an important innovation to the agricultural system of Baluchistan.

Although inoculation of lentils requires a small amount of extra labour and time, it is evident from the net benefits calculated for the experiment that this is likely to be a highly profitable innovation, particularly if the introduced rhizobia can survive in the extreme climate of Baluchistan. However, the commercial availability of adapted rhizobia in Pakistan is extremely restricted at present and it is to be hoped that in the light of the results from more widespread agronomic testing of inoculation (in progress; ICARDA, 1988) that investment to allow inoculum production on a commercial scale may be forthcoming.

The lack of response to phosphate in this experiment is somewhat surprising as P Olsen values were less than 7 mg/kg at both locations (Harmsen, 1984). However, as the phosphate status of dryland soils in upland Baluchistan is largely undetermined, these results should not be considered to be definitive, particularly as the soils are generally alkaline. This implies that phosphate responses, particularly in dry years, might be expected. Preliminary observations (ICARDA, 1988) indicate some positive responses to phosphate under dry conditions.

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REFERENCES

Anwar, R. and Sadiq, M. B. 1986. Exploration and collection of natural genetic variability of lentil in Punjab-Pakistan. Lens Newsletter 13(2):3.

Bashir, M., Alam S. S., & Bashir, A. M. 1986. In vitro evaluation of fungicides against Ascochyta lentis. Lens Newsletter 13(1):26.

Harmsen, K. 1984. Dryland barley production in Northwest Syria. III. Response to fertilizer application. Pages 151-174 in Proceedings of Soils Directorate/ICARDA Workshop on Fertilizer Use in the Dry Areas. March 1984. Aleppo, Syria.

International Center for Agricultural Research in the Dry Areas (ICARDA) 1987. High-Elevation Research in Pakistan: The MART/AZR Project Annual Report for 1986. ICARDA 110, 26 pp.

International Center for Agricultural Research in the Dry Areas (ICARDA) 1988. High-Elevation Research in Pakistan: The MART/AZR Project Annual Report for 1987. (in press)

Keatinge, J.D.H. and Rees, D.J. 1988. An analysis of precipitation and air temperature records in the Quetta Valley, Pakistan. The implications for potential improvement in agricultural production. MART/AZR Research Report 10, 13pp.

Rees, D.J., Nagy, J.G., Raza, S.H., Mahmood, K.M., Chowdhry, B.A. & Keatinge, J.D.H. 1988. The dryland arable farming system of upland Baluchistan: A case study. Proceedings of the ICARDA International Symposium on problems and prospects of winter cereals and food legumes production in high elevation areas of west and southeast Asia and North Africa. 6-10 July 1987, Ankara, Turkey, (in press).

Sandhu, P.S. 1984. Effect of sowing dates, phosphorus levels and herbicides on the response of <u>Rhizobium</u> inoculation in lentil. Lens Newsletter (11):35.

Sekhon, H.S., Dhingra, K.K., Sandhu, P.S. & Bhandari, S.C. 1986. Effect of sowing, phosphorus, and herbicides on the response to <u>Rhizobium</u> inoculation. Lens Newsletter 13(1):11.

Table 1. Climatic Data

MONTH	Quetta 1985/86 Total Rain-fall (mm)	Quetta 1985/86 Mean Max. temp.* (°C)	Quetta 1985/86 Mean Min. temp. (°C)	Quetta 1986/87 Total Rain-fall (mm)	Quetta 1986/87 Mean Max. temp. (°C)	Quetta 1986/87 Mean Min. temp. (°C)	Khuzdar 1986/87 Total Rain-fall (mm)	Khuzdar 1986/87 Mean Max. temp. (°C)	Khuzdar 1986/87 Mea Min tem (°C
Jul	0	32.0	28.0	2.0	33.7	21.8	81.3	38.2	21.9
Aug	6.5	31.0	22.0	73.2	30.0	19.0	** 380.2	37.5	20.2
Sept	0	30.6	17.1	0	30.4	10.2	0	35.0	14.0
Oct	0	25.5	4.3	0	26.4	6.1	0	35.6	9.3
Nov	0	20.5	0.0	6.9	20.2	- 0.1	4.2	27.9	4.8
Dec	50.5	12.1	- 1.0	11.4	11.7	- 3.6	0	25.7	3.3
Jan	10.1	10.7	- 4.1	28.2	12.9	-3.0	9.5	25.5	3.2
Feb	63.1	11.3	- 0.7	64.5	14.7	3.2	46.7	26.4	4.2
Mar	77.9	15.8	4.3	106.0	17.9	8.4	0	27.0	7.9
Apr	0	25.2	9.0	11.8	24.1	12.1	0	32.8	10.8
May	0	30.6	11.4	9.4	29.0	16.4	25.0	36.6	11.6

* screened air temperature at 1.5m.

** Monthly total received from two intense storms of more than 100 m each, runoff will have occurred at this site.

TABLE 2. NO. OF NODULES/PLANT AT 120 DAYS AFTER SOWING.

	QUETTA 85-86	QUETTA 86-87	KHUZDAR 86-87	MEAN	% Of EFFECT
- Phosphate	3.5	13.4	9.5	8.8	0
+ Phosphate	3.7	13.6	8.6	8.6	
- Inoculum	0	0	0	0	>100%
+ Inoculum	7.3	27.0	18.1	17.5	
Mean	3.6	13.5	9.1	8.7	
Standard Error	0.31	1.24	0.48	0.66	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	<0.1%	<0.1%	<0.1%	<0.1%	

TABLE 3. ROOT DRY WEIGHT/PLANT AFTER 120 DAYS OF SOWING(mg).

	QUETTA 85-86	QUETTA 86-87	KHUZDAR 86-87	MEAN	% OF EFFECT
- Phosphate	55.0	88.6	252.5	132.1	+13
+ Phosphate	57.0	112.5	281.3	150.4	
-Inoculum	26.3	80.0	170.0	92.1	+70
+Inoculum	86.3	121.3	363.8	190.4	
Mean	56.2	100.6	266.9	141.3	
Standard Error	2.43	10.80	7.40	6.28	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	<0.1%	<0.2%	<0.1%	<0.1%	

TABLE 4. SEED YIELD (Kg/ha)

	QUETTA 85-86	QUETTA 86-87	KHUZDAR 86-87	MEAN	% OF EFFECT
-Phosphate	37.8	620.5	369.8	342.7	+3
+Phosphate	38.0	583.0	435.6	352.2	
-Inoculum	29.8	421.4	246.0	232.4	+67
+Inoculum	46.0	782.1	559.4	462.5	
Mean	37.9	601.8	402.7	347.5	
Standard Error	2.12	35.97	37.37	24.47	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	<0.1%	<0.1%	<0.1%	<0.1%	

TABLE 5. STRAW YIELD (Kg/ha)

	QUETTA 85-86	QUETTA 86-87	KHUZDAR 86-87	MEAN	% OF EFFECT
-Phosphate	154	1680	2184	1339	-5
+Phosphate	172	1530	2122	1275	
-Inoculum	124	1079	1690	964	+52
+Inoculum	202	2130	2616	1649	
Mean	163	1605	2153	1307	
Standard Error	14.1	152.9	202.2	119.7	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	<0.1%	<0.1%	<0.1%	<0.1%	

Table 6. Net benefit analysis of lentil with and without inoculatio
at Quetta 1985-87 and Khuzdar 1986/87

	LOCATIONS					
	Quetta 1985/86		Quetta 1986/87		Khuzdar 1986/8	
	Control	Inoculum	Control	Inoculum	Control	Inoculu
Net revenue (Rs./ha)*	257	369	3127	5865	2621	5004
Net revenue gain above control (Rs./ha)	-	112	-	2738	-	2383
Marginal rate of return	320%		7823%		6809%	

Note:- Lentil seed price of Rs. 5.5/kg, straw price of Rs.0.75/k and inoculation cost of Rs. 35/ha were used in the ne benefit calculation.

* Rs. = Pakistani rupees. US$1 = (approx.) Rs. 17.5