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# Effect of fertilizers on the production potential of different crop sequences in arid regions

RAJENDRA S. YADAV AND B. L. POONIA

*Agricultural Research Station, Rajasthan Agriculture University, Mandor 342 304*

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ABSTRACT

A field experiment aimed at optimizing fertilizer use in different crop sequences, was conducted during 1991–92 and 1992–93 at Mandor (Jodhpur). Double-crop sequences recorded higher annual productivity and net return over monocrops. Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz.]–cumin (*Cuminum cyminum* L.) was found more remunerative but less sustainable compared with pearlmillet–Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] in view of higher cost and risk involved in cumin cultivation. All the double crop sequences and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) grown after fallow responded to 100% of recommended fertilizer level (RFL). Additional manuring with farmyard manure (FYM) @ 5 tonnes/ha in 91 beyond 50% of RFL improved yield of double crops for 3 consecutive seasons. Mustard and cumin grown as monocrops required to be fertilized up to 50% of RFL and additional fertilization (organic or inorganic) did not bring about improvement in productivity any further.

Many crop sequences involving pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] or fallow in rainy season (*kharif*) and Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson], cumin (*Cuminum cyminum* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) in winter season (*rabi*) are grown by cultivators under irrigated conditions in the arid regions of Rajasthan. Though sufficient research work has been done in determining fertilization schedule of these crops grown individually (Khan *et al.*, 1979 for pearlmillet; Chundawat *et al.*, 1975 for Indian mustard; Reddy and Bhardwaj, 1984 for wheat and Bhati *et al.*, 1987 for cumin), studies on working out economically viable crop sequences involving these crops along with optimization of their fertilizer requirement did not receive serious attention. Hence there is inadequate literature on this aspect for providing information to the farmers of this region. Since system-based integrated nutrient supply (organic and inorganic) approach has been reported to optimize fertilizer use (Roy and Braun, 1984), it was considered necessary and useful to study the comparative economics of these crops grown in sequence besides working out their optimized fertilizer requirement in this investigation.

## MATERIALS AND METHODS

The field experiment was conducted at Agricultural Research Station, Mandor (Jodhpur), under irrigated situation during the rainy (*kharif*) and winter (*rabi*) seasons of 1991–92 and 1992–93 at a fixed site. The soil of the experimental site was loamy sand in texture and alkaline in reaction (pH 8.2)

with low organic carbon (0.23%), moderate available phosphate (20 kg/ha) and high available potassium (235 kg/ha) status. The experiment, comprising 18 treatment combinations replicated thrice, was laid out in split-plot design with 6 crop sequences allocated to main plots and 3 fertilizer levels to subplots of size 4.5 m x 3.6 m. Crop sequences consisted of combinations of pearlmillet and fallow in *kharif* and Indian mustard, wheat and cumin grown in winter season. Three fertilizer levels comprised 50% of recommended fertilizer level (RFL), 50% RFL + FYM @ 5 tonnes/ha (FYM applied in rainy season 1991 only) and 100% of RFL applied to each crop of the sequences. Treatment of 50% of N and full quantity of phosphate for each treatment was applied basally below the seed at sowing through urea and superphosphate respectively and remaining N was top-dressed with irrigation later in the crop season. Dry sowing followed by irrigation was practised in winter-season crops to ensure good germination. Recommended package of practices (including 100% RFL) followed in the study are presented in Table 1.

## RESULTS AND DISCUSSION

### *Performance of crop sequences*

Double-crop sequences recorded higher annual productivity than the monocrop sequences under all fertilizer levels during both the years (Tables 2, 3). Average annual productivity of double-crop sequences was 3,476 kg/ha compared with 2,070 kg/ha recorded by monocrop sequences, with an additional net return of Rs 2,570/ha. But the average productivity of the winter-season crops grown after fallow recorded substantially higher yields over those grown after pearlmillet under all the fertilizer levels during both years and more so during 1991–92. It is mainly attributed to nutrient depletion by preceeding crop of pearlmillet in double-crop sequences. However, the increase in

**Table 1.** Recommended fertilizer level (100% RFL) in terms of nutrients and other package of practices followed for each crop in the experiment

| Recommended practices | Crop | | | |
|---|---|---|---|---|
| | P | IM | W | C |
| *100% RFL* | | | | |
| N (kg/ha) | 40 | 60 | 90 | 20 |
| $P_2O_5$ (kg/ha) | 20 | 40 | 40 | 20 |
| Varieties | 'MH 179' | 'T 59' | 'WH 147' | 'RZ 19' |
| Row spacing (cm) | 45 | 30 | 22 | 30 |
| Seed rate (kg/ha) | 05 | 05 | 120 | 12 |
| *Sowing date* | | | | |
| 1991–92 | 7 July | 26 Oct | 17 Nov | 17 Nov |
| 1992–93 | 28 July | 30 Oct | 19 Nov | 19 Nov |
| *Harvesting date* | | | | |
| 1991–92 | 20 Oct | 24 Feb* | 24 Mar | 13 Mar |
| 1992–93 | 21 Oct | 6 Mar | 17 Mar | 10 Mar |

P, Pearlmillet; IM, Indian mustard; W, wheat; C, cumin

average productivity of winter-season crop in monocrop system declined gradually from 319 kg/ha under 50% RFL to only 132 kg/ha under 100% RFL, owing to increased nutrient replenishment with a mean increase of 228 kg/ha. Of the crop sequences tried, pearlmillet–cumin was found most promising (with the highest net return of Rs 17,060/ha), followed by pearlmillet–Indian mustard (Rs 16,430/ha). In fact pearlmillet–Indian mustard could be considered a more sustainable crop sequence in view of more risk involved in cumin cultivation due to incidence of many diseases. Singh (1980) also found pearlmillet–Indian mustard as economically viable sequence when compared with pearlmillet–wheat (Rs 15,370/ha), these crop sequences recorded significantly higher net returns by 11.0 and 6.9% respectively. Similarly, fallow–cumin recorded significantly higher net return over fallow–wheat system by Rs 1,380/ha. Higher returns under cropping systems involving cumin and Indian mustard compared with wheat are due mainly to higher market prices fetched by these crops.

*Effect of fertility levels*

Crop productivity averaged over all crop sequences increased substantially with increasing levels of fertilization during both the years (Table 2). When compared with the 2-year average productivity of 2,555 kg/ha recorded with 50% of RFL, additional manuring with FYM @ 5 tonnes/ha in rainy season 1991 and 100% of RFL recorded average annual productivity of 2,746 kg and 3,019 kg/ha representing 7.5 and 18.2% increase respectively. Thus the 2 fertilization levels recorded average additional responses of 191 kg and 464 kg/ha with significant additional net returns of Rs 620 and 2,510/ha respectively over 50% of RFL (Table 3). However, the greater proportion of average response to additional fertilization was contributed by double-crop sequences. When compared with 2-year average annual productivity of 3,134 kg/ha recorded with 50% of RFL, additional manuring with FYM @ 5 tonnes/ha in rainy season 1991 and 100% of RFL recorded additional yield responses of 334 kg and 693 kg/ha under double crop system as also reported earlier (Hooda and Lal, 1994) as against only 50 kg and 236 kg/ha recorded under monocrop system respectively. Thus these fertilization levels registered significant additional net returns of Rs 1,300 and Rs 3,940/ha under double-cropping system respectively. Under monocrop system, only 100% of RFL recorded significantly higher additional net return of Rs 1,090/ha over 50% of RFL.

*Effect of fertilizer and crop sequences interaction*

The productivity of winter crops was affected considerably by the preceding rainy-season crop of pearlmillet. The winter crops grown after fallow recorded higher average productivity than those grown after pearlmillet. When compared with winter crops grown in sequence with pearlmillet, wheat and Indian mustard grown after fallow recorded higher productivity under all fertilizer levels. Cumin grown after fallow, however, recorded higher yield under 50% of RFL and 50% RFL + FYM only with almost similar yields under 100% RFL due probably to low nutrient requirement of this crop. Additional application of FYM @ 5 tonnes/ha in rainy season 1991 bringing about a satisfactory improvement (182 kg/ha) in yield of pearlmillet as a direct effect led to considerable improvement in yields of winter crops (230 kg/ha) in the second season and pearlmillet (215 kg/ha) in the third

**Table 2.** Seed yield of different crop sequences as affected by fertilizer levels

| Crop sequence | Seed yield (kg/ha) during 1991–92 | | | | | | Seed yield (kg/ha) during 1992–93 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50% RFL | | 50% RFL + FYM | | RFL | | 50% RFL | | 50% RFL + FYM | | RFL | |
| | RS | WS | RS | WS | RS | WS | RS | WS | RS | WS | RS | WS |
| Pearlmillet–Indian mustard | 1,975 | 1,607 | 2,001 | 1,667 | 2,150 | 1,945 | 983 | 1,683 | 1,277 | 1,765 | 1,287 | 1,893 |
| Pearlmillet–wheat | 1,872 | 3,091 | 2,181 | 3,732 | 2,325 | 3,906 | 877 | 3,055 | 1160 | 3,092 | 1,225 | 4,112 |
| Pearlmillet–cumin | 1,896 | 329 | 2,107 | 319 | 2,128 | 424 | 1,263 | 169 | 1330 | 176 | 1,370 | 191 |
| Mean (DCS) | 1,914 | 1,676 | 2,096 | 1,906 | 2,201 | 2,092 | 1,041 | 1,636 | 1256 | 1,678 | 1,294 | 2,065 |
| Fallow– Indian mustard | | 2,123 | | 1,964 | | 2,103 | | 1,762 | | 1,879 | | 1,944 |
| Fallow–wheat | | 4,092 | | 4,237 | | 4,302 | | 3,297 | | 3,492 | | 4,312 |
| Fallow–cumin | | 399 | | 394 | | 417 | | 179 | | 181 | | 190 |
| Mean (MCS) | | 2,205 | | 2,198 | | 2,274 | | 1,746 | | 1,851 | | 2,149 |
| Mean (F levels) | 957 | 1,940 | 1,048 | 2,052 | 1,101 | 2,183 | 521 | 1,691 | 628 | 1,764 | 647 | 2,107 |

RFL, Recommended fertilizer level; DCS, double-crop sequences
MCS, Monocrop sequences
RS, Rainy season; WS, winter season

**Table 3.** Seed yield (average data of 2 years) and net return (pooled data) of different crop sequences as affected by fertility levels

| Crop sequence | Seed yield (kg/ha) | | | | | | | | Net returns (Rs x $10^{-3}$/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50% RFL | | 50% RFL + FYM | | RFL | | Mean (CS) | | 50% RFL | 50% RFL + FYM | RFL | Mean |
| | RS | WS | RS | WS | RS | WS | RS | WS | | | | |
| Pearlmillet–Indian mustard | 1,479 | 1,645 | 1,639 | 1,716 | 1,719 | 1,919 | 1,612 | 1,760 | 15.17 | 16.24 | 17.89 | 16.43 |
| Pearlmillet–wheat | 1,375 | 3,073 | 1,671 | 3,412 | 1,775 | 4,009 | 1,607 | 3,498 | 12.95 | 15.18 | 17.99 | 15.37 |
| Pearlmillet–cumin | 1,580 | 249 | 1,719 | 248 | 1,749 | 308 | 1,682 | 268 | 15.52 | 16.09 | 19.56 | 17.06 |
| Mean | 1,478 | 1,656 | 1,676 | 1,792 | 1,748 | 2,079 | 1,634 | 1,842 | 14.54 | 15.84 | 18.48 | 16.29 |
| Fallow–Indian mustard | | 1,943 | | 1,922 | | 2,024 | | 1,963 | 13.75 | 13.26 | 14.12 | 13.71 |
| Fallow–wheat | | 3,695 | | 3,865 | | 4,307 | | 3,955 | 12.13 | 12.79 | 14.18 | 13.03 |
| Fallow–cumin | | 289 | | 288 | | 304 | | 293 | 14.25 | 13.92 | 15.07 | 14.41 |
| Mean | | 1,975 | | 2,025 | | 2,211 | | 2,070 | 13.37 | 13.33 | 14.46 | 13.72 |
| F means | 739 | 1,816 | 838 | 1,908 | 874 | 2,145 | 817 | 1,956 | 13.96 | 14.58 | 16.47 | 15.00 |
| *CD (P = 0.05) for net return* | | | | | | | | | | | | |
| Crop sequences | | | | 0.98 | | | | | | | | |
| Fertility levels (F) | | | | 0.60 | | | | | | | | |
| Fertility levels at the same cropping sequence | | | | 1.46 | | | | | | | | |
| Cropping sequence at the same fertility level | | | | 1.55 | | | | | | | | |
| Cropping systems (CS) | | | | 0.57 | | | | | | | | |
| Fertilizer levels within cropping systems | | | | 0.85 | | | | | | | | |

RS, Rainy season; WS, winter season

season due to its residual effects over 50% RFL. The yields of winter crops in the fourth season (winter 1992–93) did not improve due possibly to depletion of its residual effect. The 100% of RFL, however, considerably improved yields of pearlmillet and all the winter crops grown in double crop sequence during both the years over 50% RFL due to nutrient replenishment every season. But in monocrop sequences there was no response to additional fertilization beyond 50% RFL, especially by Indian mustard and cumin because of their low nutrient requirement combined with nutrient build-up during fallowing. It was only wheat crop which responded considerably to additional fertilization (organic or inorganic) beyond 50% of RFL under this system during both the years.

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