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Production Potential, Moisture Use and Economic Viability of Pearl Millet (*Pennisetum glaucum*) Intercropped with Moth Bean (*Vigna aconitifolia*) under Rainfed Situations

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Abstract: A field experiment was conducted at research farm, IARI, New Delhi, in two consecutive rainy (kharif) seasons (2003 and 2004), on sandy loam soil to evaluate the effect of cropping system, fertility levels and moisture conservation practices on the productivity, moisture use and economics of pearl millet (*Pennisetum glaucum*) under rainfed conditions. Paired row of pearl millet (30/70 cm) + moth bean (1 row) intercropping system gave higher pearl millet grain equivalent yield (2960 kg ha^{-1}), net monetary return (Rs. 8375 ha^{-1}), monetary return efficiency (Rs. 107.37 ha^{-1} day^{-1}) as well as WUE (8.34 kg ha^{-1} mm^{-1}) and total rain use efficiency (4.79 kg ha^{-1} mm^{-1}) than sole pearl millet. Application of 80 kg N + 40 kg P_2O_5 ha^{-1} produced significantly higher grain (2881 kg ha^{-1}), stover yield (8278 kg ha^{-1}), pearl millet grain equivalent yield (3140 kg ha^{-1}), net monetary return (Rs. 9126 ha^{-1}), monetary return efficiency, WUE and RUE over no fertilization, but statistically at par with 40 kg N + 20 kg P_2O_5 ha^{-1}. Adoption of moisture conservation practices of FYM @ 5 t ha^{-1} + dust mulch + straw mulch resulted in significantly higher pearl millet equivalent yield, net monetary return, monetary returns efficiency and maximum WUE over rest of the moisture conservation practices.

Key words: Pearl millet, moth bean, intercropping, fertility levels, moisture conservation, production potential, moisture use pattern, economic viability.

The area under rainfed farming is 67% and contributes 42% of the total national food grain production. The arable land is a precious and scares resource and farmers give less attention towards millets and pulse crops in soils rich in fertility therefore, among the options to increase the productivity, cropping intensity and efficient utilization of available resources to derive maximum output per unit of land may be through intercropping systems. The biological sustainability can be maintained by intercropping of legumes with cereals. It also improves the nitrogen status of the soil and thus, reduces the requirement of chemical fertilizers for efficient utilization of water, nutrients and light (Shaikh *et al*., 1994). Pearl millet productivity can be improved through agronomic manipulations including fertilizers and moisture conservation practices i.e., mulches, anti-transpirants and planting methods (Jat and Gautam, 2000). Use of organic manure and mid-season corrections enhance water productivity by pearl millet. Judicious use of fertilizers at right place also enhances nutrient use efficiency and crop productivity. Pearl millet is an indispensable cereal crop of the arid and semi-arid regions of India. It occupies 8.7 M ha area with 8.9 M t production with an average productivity of 1014 kg ha^{-1} (GOI, 2009-10), which is quite low due to poor water holding capacity of sandy soils, low input use efficiency and inadequate use of nutrients. Under rainfed conditions of arid and semi-arid regions only one season is available for cropping, so that farmers have option to raise two or more crops on the same piece of land to derive maximum input use efficiency per unit of land through inclusion of legumes which covers soil, reduces evaporation losses, improves soil health and gives additional yield and returns (Ali, 1998). Therefore, present study was undertaken to find out the best moisture conservation practice with efficient use of fertilizer for improving pearl millet productivity and profitability.

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Materials and Methods

The field experiment was conducted at the research farm, Division of Agronomy, IARI, New Delhi, for two consecutive rainy (*kharif*) seasons (2003 and 2004). The maximum and minimum temperatures during the growing season fluctuated between 29.6 and 33.9°C and 17.6 and 27.0°C, respectively in 2003 and 30.3 and 39.0°C and 19.3 and 27.8°C in 2004 and relative humidity was between 55.4 and 88.0% in 2003 and 56.0 and 85.5% in 2004. The rainfall received during growing period was 810.3 in 2003 and 425.4 mm in 2004. In the first

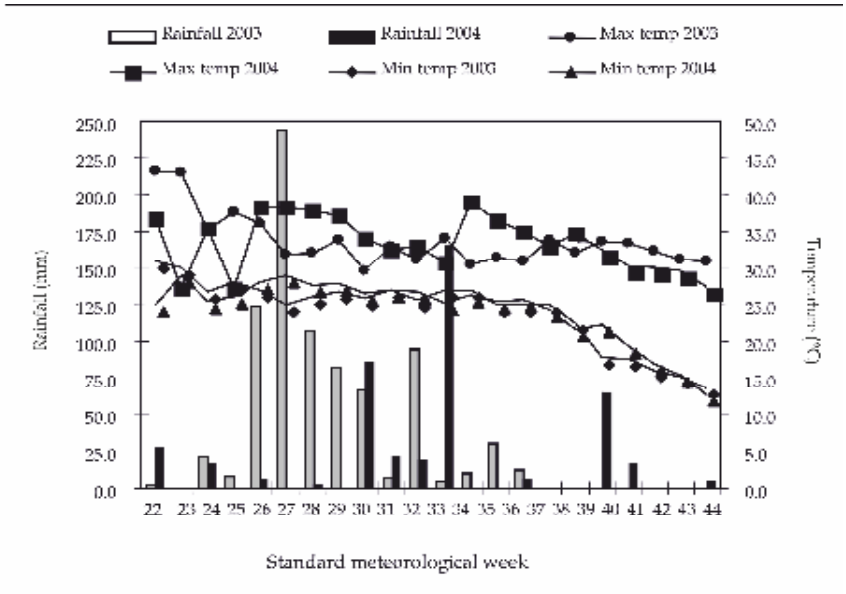

Fig. 1. Weather parameters recorded during crop growth period

year good weather conditions and high rainfall seem favourable for higher yield and delayed sowing with low rainfall resulted in low yield in the second year. The soil at the experimental site was sandy loam having bulk density 1.50 Mg m^{-3} with neutral soil pH (7.7), poor in organic carbon (0.40%), low in available N (251 kg ha^{-1}), medium in available P (16.4 kg ha^{-1}) and high in available K (316 kg ha^{-1}). The temperatures and precipitations during experimented period are presented in Fig.1.

The experiment was conducted in split-plot design with three replications. The treatment combinations comprized of two cropping systems [sole pearl millet (50 cm row spacing) and pearl millet paired planting (30/70 cm row spacing) + one row of moth bean] and three fertility levels (control, 40 kg N + 20 kg P_2O_5 ha^{-1} and 80 kg N + 40 kg P_2O_5 ha^{-1}) in main plots and four moisture conservation practices (no mulch, dust mulch + straw mulch, kaolin + straw mulch and FYM @ 5 t ha^{-1} + dust mulch + straw mulch) in sub-plots. The hybrid 'Pusa-605' of pearl millet and 'RMO-40' of moth bean varieties treated with bavistin @ 2 g kg^{-1} seed were sown in rows 50 cm apart for sole and in intercropping pearl millet was sown in paired row at 30 cm keeping 70 cm distance between two pairs to adjust one row of moth bean intercrop (30/70 cm). The component crop was sown with country plough on 15th July in 2003 and 31st July in 2004. The fertilizers were applied as per treatments viz., no nutrient, 40 kg N + 20 kg P_2O_5 ha^{-1} and 80 kg N + 40 kg P_2O_5 ha^{-1} to pearl millet in earmarked plots. The FYM was incorporated as per treatment during both the years. The dust mulching was created twice at 25 DAS and 40 DAS of pearl millet in the earmarked plots during both the years.

The kaolin (6% suspension) as anti-transpirant was sprayed over crop foliage at 50 DAS during both the years. The pearl millet was harvested on 6th October 2003 and 10th October 2004, and moth bean on 25th September 2003 and 3rd October 2004. Pearl millet was harvested on drying of the ears, however, in moth bean pods were picked twice. After complete sun drying, the bundles and pods were weighed for biological yield. The total rain use efficiency (TRUE) was calculated following Devasenapathy *et al*. (2008) as ratio of economic output per unit area (pearl millet equivalent yield) to the total rainfall received during the crop season. The monetary return efficiency (MRE) was calculated as ratio of net return (Rs. ha^{-1}) to the mean crop duration (days). The consumptive use of water by the crop under different treatments was computed using the formulae described by Dastane (1972).

Results and Discussion

Yield components

Cropping system had non significant effect on yield components of pearl millet while, sole pearl millet gave markedly higher yield components viz., number of earhead m^{-1} row, earhead length, earhead girth and 1000-grain weight in comparison to pearl millet intercropped with moth bean (Table 1). The application of graded levels of 80 kg

Table 1. Effect of cropping system, fertility levels and moisture conservation practices on yield components of pearl millet and moth bean under rainfed situations (Pooled data of 2 years)

Treatments	Pearl millet				Moth bean			
	Earhead m^{-1} row	Earhead length (cm)	Earhead girth (cm)	1000-grain weight (g)	Pods $plant^{-1}$	Grains pod^{-1}	Grain weight pod^{-1} (g)	1000-grain weight (g)
Cropping system								
C_1: Pearl millet sole (50 cm)	13.68	25.81	7.81	6.68	-	-	-	-
C_2: Pearl millet paired row (30/70 cm) + one row of moth bean	13.21	25.20	7.69	6.54	21.78	5.05	0.12	27.98
CD (P= 0.05)	NS	NS	NS	NS	-	-	-	-
Fertility levels								
F_0: Control	10.01	21.43	7.33	6.46	19.10	4.35	0.09	27.47
F_1: 40 kg N + 20 kg P_2O_5 ha^{-1}	14.87	27.03	7.9	6.66	22.68	5.28	0.14	28.27
F_2: 80 kg N + 40 kg P_2O_5 ha^{-1}	15.46	28.06	8.02	6.72	23.58	5.52	0.15	28.22
CD (P= 0.05)	0.82	1.27	0.32	NS	2.27	0.33	0.01	NS
Moisture conservation practices								
M_0: No mulch	10.27	22.43	7.10	6.43	19.02	4.34	0.10	27.59
M_1: Dust mulch + straw mulch	13.19	24.84	7.76	6.58	21.90	5.05	0.12	28.04
M_2: Kaolin + straw mulch	14.08	25.78	7.78	6.64	22.01	5.09	0.13	28.13
M_3: FYM @ 5 t ha^{-1} + dust mulch + straw mulch	16.24	28.98	8.37	6.80	24.21	5.70	0.14	28.19
CD (P= 0.05)	1.13	1.64	0.65	NS	1.9	0.49	0.01	NS

N + 40 kg P_2O_5 ha^{-1} remained statistically at par with 40 kg N + 20 kg P_2O_5 ha^{-1}, but recorded significantly higher values of yield components viz., number of earhead m^{-1} row (15.46), earhead length (28.06 cm) and earhead girth (8.02 cm) of pearl millet and number of pods $plant^{-1}$ (23.58), grains pod^{-1} (5.52) and grain weight pod^{-1} (0.15 g) in moth bean over control. The improvement in yield components could be due to favorable influence of nitrogen and phosphorus on the growth parameters of both the crops. The results are in agreement with those of Bhagchand and Gautam (2000). Moisture conservation practices of FYM @ 5 t ha^{-1} + dust mulch + straw mulch recorded significantly higher values of yield components of pearl millet as well as moth bean followed by kaolin + straw mulch, dust mulch + straw mulch and lowest with no mulch. This could be due to the combined effect of these components in more effectively reducing the evapotranspiration losses and increasing water holding capacity of the soil (Kaushik and Lal, 1997).

Crop yield

The cropping system did not influence the grain and stover yields of pearl millet (Table 2), and maximum grain and stover yields of pearl millet were recorded in sole cropping, perhaps planting system did not influence grain and stover yields of pearl millet at fix plant population. Similar results were also reported by Goswami *et al.* (2002). Application of graded doses of fertilizers significantly increased the grain and stover yields of pearl millet as well as moth bean over no fertilization. Application of 80 kg N + 40 kg P_2O_5 ha^{-1} remained at par with 40 kg N + 20 kg P_2O_5 ha^{-1}, but recorded significantly higher grain (2881 kg ha^{-1}) and stover (8278 kg ha^{-1}) yields of pearl millet over control and registered 701 and 2781 kg ha^{-1} of grain and stover yield over no fertilization, respectively. Similarly, higher moth bean grain (167 kg ha^{-1}) and stover (410 kg ha^{-1}) yields were recorded in comparison to control. It could be attributed to the higher availability of N and P leading to better growth and development, which ultimately resulted in higher yield. Sharma and Gupta (2002) also reported linear increase in the yield of pearl millet with increase in the dose of N and P. Moisture-conservation practices markedly influenced the grain and stover yields of pearl millet and moth bean (Table 2). Application of FYM @ 5 t ha^{-1} + dust mulch + straw mulch gave significantly higher grain (3017 kg ha^{-1}) and straw (8651 kg ha^{-1}) yields over rest of the treatments. The treatments kaolin + straw mulch gave 2711 and 7469 kg ha^{-1} and dust mulch + straw mulch of 2594 and 6977 kg ha^{-1} compared to no mulch 2076 and 5593 kg ha^{-1} of grain and stover yield, respectively. Similar trends were also observed in the grain and stover yields of moth bean. While, application of kaolin + straw mulch (144 and 361 kg ha^{-1}) remained at par with

Table 2. Effect of cropping system, fertility levels and moisture conservation practices on productivity, moisture use and economics of pearl millet under rainfed conditions (Pooled data of 2 years)

Treatment	Yield (kg ha^{-1})					Water use		Economics	
	Pearl millet		Moth bean		PEY	WUE (kg ha^{-1} mm^{-1})	TRUE (kg ha^{-1} mm^{-1})	NMR (Rs ha^{-1})	Monetary return efficiency (Rs ha^{-1} day^{-1}*)
	Grain	Stover	Grain	Stover					
Cropping system									
C_1: Pearl millet sole (50 cm)	2660	7374	-	-	2660	8.07	4.31	7477	95.86
C_2: Pearl millet paired row (30/70 cm) + one row of moth bean	2539	6972	135	338	2960	8.34	4.79	8375	107.37
CD (P= 0.05)	NS	NS	-	-	166	-	-	620	-
Fertility levels									
F_0: Control	2180	5497	85	220	2314	7.19	3.75	5812	74.51
F_1: 40 kg N + 20 kg P_2O_5 ha^{-1}	2737	7745	154	386	2978	8.52	4.82	8988	115.23
F_2: 80 kg N + 40 kg P_2O_5 ha^{-1}	2881	8278	167	410	3140	8.90	5.08	9126	117.00
CD (P= 0.05)	200	634	20	51	203	-	-	680	-
Moisture conservation practices									
M_0: No mulch	2076	5593	85	213	2208	6.95	3.57	5918	75.87
M_1: Dust mulch + straw mulch	2594	6977	138	346	2809	8.29	4.55	7873	100.94
M_2: Kaolin + straw mulch	2711	7469	144	361	2936	8.38	4.75	8058	103.31
M_3: FYM @ 5 t ha^{-1} + dust mulch + straw mulch	3017	8651	174	435	3289	9.20	5.32	10051	128.86
CD (P= 0.05)	235	711	29	42	238	-	-	890	-

*Mean crop duration 78 days, PEY=Pearl millet Equivalent Yield, WUE=Water use efficiency, TRUE=Total rain use efficiency

dust mulch + straw mulch (138 and 346 kg ha^{-1}), but statistically superior over no mulch (85 and 213 kg ha^{-1}), respectively. The increase in productivity of grain and stover with moisture-conservation practices of FYM, dust and straw mulches, which might extend the period of water storage in the soil profile by reducing the evaporation and transpirational losses of water from soil and plant foliage, whereas FYM increases water-holding capacity in the soil. These results corroborate the findings of Jat and Gautam (2001) in pearl millet.

Pearl millet-equivalent yield

Pearl millet intercropped with moth bean recorded significantly higher pearl millet equivalent yield (2960 kg ha^{-1}) over sole pearl millet (2660 kg ha^{-1}) and was registered to the tune of 11.3% higher over sole pearl millet due to harvest of additional yield of moth bean and its higher market price (Table 2). These results were in close conformity with those of Tetarwal and Nanwal (2002). Application of 80 kg N + 40 kg P_2O_5 ha^{-1} recorded significantly higher pearl millet equivalent yield (3140 kg ha^{-1}) over control (2314 kg ha^{-1}), which was at par with 40 kg N + 20 kg P_2O_5 ha^{-1} (2978 kg ha^{-1}). The increase in grain equivalent yield was 35.7% over control, probably increase in economic yields of both the component crops due to application of nitrogen and phosphorus. Application of FYM @ 5 t ha^{-1} + dust mulch + straw mulch recorded significantly higher pearl millet equivalent yield (3289 kg ha^{-1}) as compared to kaolin + straw mulch (2936 kg ha^{-1}), dust mulch + straw mulch (2809 kg ha^{-1}) and no mulch (2208 kg ha^{-1}). The treatment kaolin + straw mulch produced higher pearl millet equivalent yield over no mulch, but it was found to be at par with dust + straw mulch.

Moisture use pattern

The water-use efficiency (WUE) and rain-use efficiency (RUE), in terms of pearl millet equivalent yield showed marked variation due to all treatments (Table 2). Pearl millet paired row + one row of moth bean recorded higher WUE as well as RUE over sole crop. This might be due to higher grain yield of both the crops than the sole pearl millet, with same amount of water. These results are in close conformity with Goswami *et al*. (2002). The highest WUE and RUE was recorded with 80 kg N + 40 kg P_2O_5 ha^{-1} closely followed by 40 kg N + 20 kg P_2O_5 ha^{-1} and was least in no fertilization. The moisture conservation practices of FYM @ 5 t

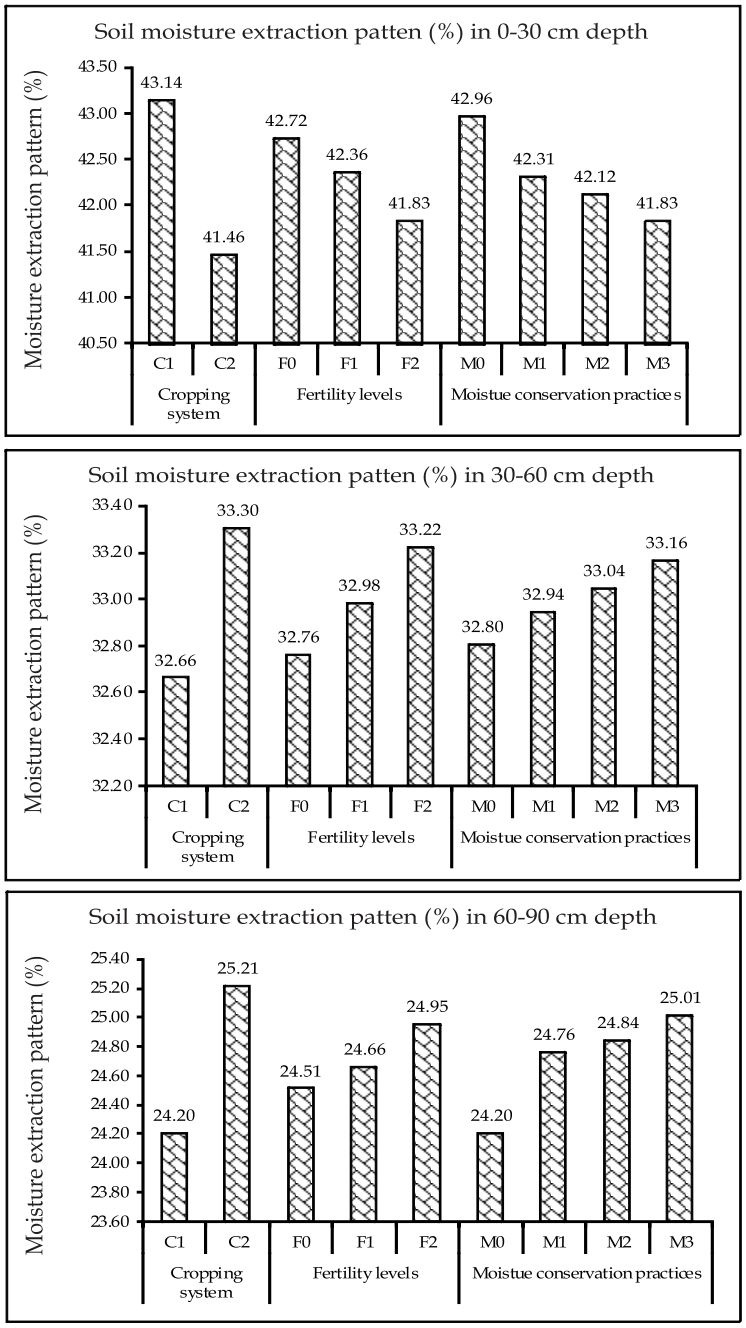

Fig: 2. Moisture extraction pattern in different soil depths.

ha^{-1} + dust mulch + straw mulch treatment gave the highest WUE (9.20 kg ha^{-1} mm) as well as RUE (5.32 kg ha^{-1} mm) and were lowest with no mulch (6.95 and 3.57 kg ha^{-1} mm). The moisture conservation practices increased the availability of soil moisture and water holding capacity due to addition of FYM ultimately enhancing the crop growth. These results are in agreement with those of Das and Gautam (2003) in pearl millet. Maximum soil moisture depletion (42.96%) was registered from top soil (0-30 cm) in no mulch, while least (41.83%) was recorded with FYM @ 5 t ha^{-1} + dust mulch + straw mulch. This was due to slow canopy development, which exposed the soil surface to solar radiation leading to higher evaporation. However, the reverse was true in deeper soil layers 30-60 and 60-90 cm, where maximum percentage of moisture was depleted with FYM @ 5 t ha^{-1} + dust mulch + straw mulch (33.16 and 25.01%) followed by kaolin + straw mulch (33.04 and 24.84%), dust mulch + straw mulch (32.94 and 24.76%) and no mulch (32.80 and 24.20%, respectively). This was

mainly because of more moisture availability in the deeper soil layers with the different moisture conservation practices (Fig. 2).

Economic viability

The economic feasibility in terms of net monetary return and monetary return efficiency showed that cropping system markedly influenced the profitability of pearl millet + moth bean system over sole pearl millet. The significantly higher net monetary return (Rs. 8375 ha^{-1}) and monetary return efficiency (Rs. 107.37 ha^{-1} day^{-1}) were recorded in pearl millet + moth bean intercropping system compared with sole pearl millet (Table 2). Inclusion of moth bean as intercrop gave additional yield with their high market price and also increased pearl millet grain equivalent yield, thus ultimately gave higher net monetary return and monetary return efficiency. Ram and Choudhary (2002) found that pearl millet intercropped with cluster bean and green gram gave significantly higher net return and B:C ratio over sole crop of pearl millet. Application of 80 kg N + 40 kg P_2O_5 ha^{-1} fetched significantly higher net monetary return (Rs. 9126 ha^{-1}) over control (Rs. 5812 ha^{-1}), but it remained at par with 40 kg N + 20 kg P_2O_5 ha^{-1}. The highest monetary return efficiency (Rs. 117.0 ha^{-1} day^{-1}) was fetched with 80 kg N + 40 kg P_2O_5 ha^{-1} closely followed by 40 kg N + 20 kg P_2O_5 ha^{-1} (Rs. 115.23 ha^{-1} day^{-1}) and lowest with control (Rs. 74.51 ha^{-1} day^{-1}). These results are in close conformity with the results of Tetarwal and Nanwal (2001). Adoption of moisture conservation with application of FYM @ 5 t ha^{-1} + dust mulch + straw mulch recorded highest monetary return efficiency (Rs. 128.86 ha^{-1} day^{-1}) which was 69.8, 27.6 and 24.7% higher over no mulch, dust mulch + straw mulch and kaolin + straw mulch, respectively. The maximum net monetary returns (Rs. 10051 ha^{-1}) was recorded with application of FYM @ 5 t ha^{-1} + dust mulch + straw mulch over rest of the moisture conservation practices. This might be due to significantly higher pearl millet-equivalent yield owing to increased net monetary return.

References

Ali, M. 1988. Weed suppressing ability on productivity of short duration legumes intercropped with pigeonpea under rainfed condition. *Tropical Pest Management* 34(4): 384-387.

Bhagchand and Gautam, R.C. 2000. Effect of organic manure, biofertilizers and inorganic fertilizers on growth, yield and quality of rainfed pearl millet. *Annals of Agricultural Research* 21(4): 459-464.

Das, G. and Gautam, R.C. 2003. Yield and water use efficiency of pearl millet as influenced by moisture conservation methods under rainfed conditions. *Annals of Agricultural Research* 24(1): 78-81.

Dastane, N.G. 1972. *A Practical Manual for Water Use Research in Agriculture*. Poona (Maharashtra) Navbharat Prakashan.

Devasenapathy, P., Ramesh, T. and Gangwar, B. 2008. *Efficiency Indices for Agriculture Management Research*. New India Publishing Agency, New Delhi.

GOI, 2009-10. *Economic Survey*, Ministry of Finance and Company Affairs, Economic Division. New Delhi.

Goswami, V.K., Kaushik, S.K. and Gautam, R.C. 2002. Effect of intercropping and weed control on nutrient uptake and water use efficiency of pearl millet (*Pennisetum glaucum*) under rainfed conditions. *Indian Journal of Agronomy* 47(4): 504-508.

Jat, M.L. and Gautam, R.C. 2000. Effect of summer ploughing and *in-situ* moisture conservation practices on growth and yield of rainfed pearl millet (*Pennisetum glaucum*). *Indian Journal of Agronomy* 45(4): 722-727.

Jat, M.L. and Gautam, R.C. 2001. Productivity and water use of rainfed pearl millet (*Pennisetum glaucum*) as influenced by summer ploughing and *in-situ* moisture conservation practices under semi-arid conditions of north-west India. *Indian Journal of Agronomy* 46(2): 266-272.

Kaushik, S.K. and Lal, K. 1997. Relative efficiency of mulches and antitranspirants on productivity and water-use efficiency of rainfed pearl millet (*Pennisetum glaucum*). *Indian Journal of Agronomy* 46(2): 104-106.

Ram, B. and Choudhary, G.R. 2002. Productivity and profitability of pearl millet as influenced by weed management and intercropping systems under semi-arid region of Rajasthan. *Journal of Farming System Research and Development* 8(1&2): 135-138.

Reddy, D.S. 1986. Effect of straw and soil mulches on moisture retention and yield under rainfed agriculture. *Journal of Research APAU* 14**:** 148-152.

Shaikh, A.A., Jadhav, A.S., Koli, B.D. and Wattamwar, M.J. 1994. Effect of planting layouts, mulching and fertilizers on dry matter accumulation and energy relationship in rainfed pearl millet. *Journal of Maharashtra Agricultural University* 19(3): 421-423.

Sharma, O.P. and Gupta, A.K. 2002. Nitrogen-phosphorus nutrition of pearl millet as influenced by intercrop legumes and fertilizer levels. *Journal of Plant Nutrition* 25(4): 833-842.

Tetarwal, J.P. and Nanwal, R.K. 2001. Yield and nutrient uptake in pearl millet intercropping system as influenced by fertilizer application under rainfed conditions. *Journal of Farming System Research and Development* 7(1): 107-110.

Tetarwal, J.P. and Nanwal, R.K. 2002. Productivity of pearl millet (*Pennisetum glaucum*) as influenced by cropping systems and fertilization under rainfed conditions. *Agronomy Digest* 2: 8-11.