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Response of foliar application of liquid organic manures on plant growth, productivity and economics of pearl millet + clusterbean intercropping system

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Abstract

A field experiment was conducted during *kharif* season of 2022 and 2023 at Jobner (Rajasthan) to assess the response of foliar application of various liquid organic manures on growth, productivity and economics of pearl millet + clusterbean intercropping system. The experiment was laid out in split plot design with 3 replications comprising six intercropping systems viz., pearl millet + clusterbean (1:1), (2:1), (1:2), (2:2), pearl millet sole and clusterbean sole in main plots and four liquid organic manure treatments viz., control, 10% vermiwash, 3% panchgavya and 10% cow urine in subplots. Pooled analysis of 2 years showed that sole pearl millet recorded significantly higher plant height of pearl millet at 60 DAS (147.9 cm) and harvest (163.6 cm). However, pearl millet + clusterbean (1:2) intercropping system registered significantly maximum dry matter accumulation of pearl millet at 60 DAS (38.3 g/plant) and at harvest (50.2 g/plant). In clusterbean, pearl millet + clusterbean (2:1) recorded significantly higher plant height of 66.1 cm, 89.3 cm and 94.0 cm at 60, 90 DAS and at harvest, respectively, while sole clusterbean recorded maximum dry matter accumulation of 12.4 g, 21.2 g and 23.9 g/plant at corresponding stages. Among liquid organic manures, foliar spray of 3% panchgavya significantly enhanced plant height, dry matter accumulation and productivity of both crops and remained statistically at par with 10% vermiwash. The highest pearl millet equivalent yield (2910 kg/ha) was recorded under pearl millet + clusterbean (1:2), whereas significantly maximum land equivalent ratio (1.26), net returns (62,923 ₹/ha) and B:C ratio (2.54) were obtained under pearl millet + clusterbean (2:2). Foliar spray of 3% panchgavya recorded highest PEY (2697 kg/ha), net returns (60,086 ₹/ha) and B:C ratio (2.39).

Keywords: Intercropping, panchgavya, pearl millet equivalent yield, dry matter accumulation, land equivalent ratio, economics

Introduction

Pearl millet (*Pennisetum glaucum* (L.) R. Br. Emend Stuntz) is one of the most important crops and occupies a pride place in the agricultural economy of arid and semi-arid regions of our country. It is crop of arid areas where soils are mainly loamy sand with low fertility, poor microbial activity, low organic matter content, high infiltration rate, poor moisture storage retention and precarious rainfall. Among the major food grain crops grown in India, pearl millet ranks fourth in the acreage, next to rice, wheat and maize. It also occupies an important place in the daily diet of many classes of people in India. Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub} popularly known as 'Guar' is a drought hardy crop and belonging to the family Fabaceae. It is a good source of carbohydrate (38.8 to 59.0%) with high crude protein (28.3 to 35.0%), gum (23.9 to 35.0%), crude fibre (4.15 to 8.0%), ash (3.5 to 6.0%) and fat content (1.8 to 5.2%). Guar bean, is indeed an excellent source of several important amino acids, including glutamic, arginine, aspartic acid and leucine. Guar is an extremely valuable legume in crop rotations due to its nitrogen-fixing ability. By enriching the soil with nitrogen, it reduces the need for synthetic fertilizers, enhances soil fertility and supports sustainable farming practices. Due to high capacity to recover from water stress it is one of the best legume crops for the climatic situation of Rajasthan (Sharma *et al.*, 2018) [12]. Intercropping is one of the greatest option and potentially advantageous cropping approach because it uses almost the same number of total resources

while increasing overall output (Pawar and Khanna, 2018) [8]. The basic principle entails sowing two or more crops with the assumption that two crops will exploit the environment better than one crop resulting in higher yield output since both crops use different resources at different times and complement each other (Yadav *et al.*, 2015) [16]. In drought prone areas particularly Rajasthan, pearl millet and clusterbean intercropping is the most frequently accepted system that can offer some yield in the event that the main crop fails. This system often has complementary growth habits that allow for efficient use of sunlight and different nutrient requirements. Pearl millet can efficiently utilize soil nitrogen and clusterbean as a legume possesses the ability to fix atmospheric nitrogen with the aid of nitrogen fixing bacteria in its root nodules leading to improved nutrient utilization in the system. Application of liquid organic manures like panchgavya, vermiwash and cow urine through foliar spray enhances nutrient availability, microbial activity and growth-promoting hormones, thereby improving crop growth and yield. Liquid organic manures have natural antifungal and antibacterial characteristics, increases disease resistance and act as a protective barrier to assist plants tolerate environmental stresses such as drought, heat and other adverse conditions. It could enhance crop resilience and plant development (Sreenivasa *et al.*, 2010) [14]. Panchagavya can also improve the photosynthetic process, sugar production in plants, boost flowering and fruit set in crops potentially leading to greater yield. It also retouches microbial activity on plant surfaces and magnifies a healthy soil microbiome (Shubha *et al.*, 2014) [13]. However, information regarding the effect of intercropping systems and liquid organic manures on growth dynamics, productivity and economics of pearl millet + clusterbean intercropping system under arid conditions is limited. Therefore, the present investigation was undertaken.

Materials and Methods

A field experiment was conducted during *kharif* 2022 and 2023 at Instructional Farm, Department of Agronomy, SKNCOA, Jobner (Rajasthan). Rainfall received during the crop period was 5.00 mm to 93.00 and 6.00 to 107.4 mm during *kharif* season of 2022 and 2023, respectively. The soil of the experimental field was sandy loam in texture with low available nitrogen, medium phosphorus and potassium status. The experiment was laid out in split plot design with three replications. The experiment comprised six intercropping systems viz., pearl millet + clusterbean (1:1), pearl millet + clusterbean (2:1), pearl millet + clusterbean (1:2), pearl millet + clusterbean (2:2), pearl millet sole and clusterbean sole along with four liquid organic manure treatments viz., control, 10% vermiwash, 3% panchgavya and 10% cow urine. Pearl millet variety RHB 234 and clusterbean variety RGC 1033 were used for sowing. The crops were sown with row spacing of 30 cm using seed rate of 4 kg/ha for pearl millet and 15 kg/ha for clusterbean. The gross plot size was 3.6 × 4.0 m² (14.4 m²), whereas net plot size was 2.4 × 3.0 m² (7.2 m²). Fertilizer application, irrigation and weed management practices were carried out as per treatments and recommended agronomic practices. Observations on plant height, dry matter accumulation, pearl millet equivalent yield (PEY), land equivalent ratio (LER), net returns and benefit-cost ratio were recorded following standard procedures and analysed statistically using analysis of variance appropriate for split plot design.

Five plants were randomly selected and tagged from the net plot area of each treatment for recording plant height and dry matter accumulation. Plant height was measured with the help of a

metre scale from the base of the plant to the tip of the uppermost leaf during vegetative stage and up to the base of earhead during reproductive stage in pearl millet, while in clusterbean it was measured up to the topmost growing point. The mean value was computed and expressed in centimetres. For recording dry matter accumulation, five representative plants were uprooted from each plot, sun dried for 3-4 days and subsequently oven dried at 65°C until constant weight was obtained. The dry weight was recorded with the help of an electronic weighing balance and expressed as g/plant.

The pearl millet equivalent yield (PMY) was calculated on the basis of formula given below

$$\text{Pearlmillet Equivalent Yield (kg/ha)} = \frac{\text{Yield of pearl millet (kg/ha)} \times \text{Yield of intercrop (kg/ha)}}{\text{Price of intercrop (₹/kg)}} \div \frac{\text{Price of pearl millet (₹/kg)}}{\text{Price of pearl millet (₹/kg)}}$$

On the basis of current market price, grain yield of different crop was converted and summed up to the yield of pearl millet crop grain yield respectively and pearl millet grain equivalent was obtained.

LER denotes the relative land area under sole crop requires to produce the same yield as obtained under a mixed or an intercropping system at the same management level. It is calculated as sum total of the ratios of the yield of each component crop in an intercropping system to its corresponding yield when grown as a sole crop.

$$\text{LER} = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

Net return (₹/ha) and benefit cost ratio (B:C) were calculated to evaluate the economic. Net return/ha were calculated by deducting the cost of cultivation of respective treatments from gross monetary return for the corresponding treatments.

Net return = Gross return (₹/ha) – Cost of cultivation (₹/ha).

The benefit cost ratio of each treatment was calculated by dividing the gross return with the cost of cultivation.

$$\text{Benefit - cost ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

Results and Discussion

Plant Height

Pearl millet

In pearl millet, plant height at 30 DAS remained non-significant under different intercropping systems, however, significant differences were observed at 60 DAS and at harvest. Sole pearl millet recorded significantly maximum plant height of 147.9 cm at 60 DAS and 163.6 cm at harvest over pearl millet + clusterbean (2:1), pearl millet + clusterbean (2:2), pearl millet + clusterbean (1:1) and pearl millet + clusterbean (1:2), respectively. Taller plants in sole pearl millet may be attributed to intense intra-row competition for light, resulting in greater cell elongation and auxin activity. Similar findings were also reported by Renu *et al.*, (2018) [11]. Among liquid organic manures, foliar spray of 3% panchgavya significantly enhanced pearl millet plant height and recorded maximum values of 133.9 cm at 60 DAS and 150.3 cm at harvest. Panchgavya contains macro and micronutrients along with growth-promoting substances like auxins, gibberellins and beneficial microorganisms which stimulate cell division and elongation, thereby improving vegetative growth. Similar results were

reported by Patel *et al.*, (2021) ^[7] and Mushar *et al.*, (2023) ^[6].

Clusterbean

In clusterbean, intercropping systems significantly influenced plant height at 60, 90 DAS and at harvest stage. Pearl millet + clusterbean (2:1) recorded significantly higher plant height of 66.1 cm (60 DAS), 89.3 cm (90 DAS) and 94.0 cm (at harvest), respectively. The increase in plant height under this treatment was mainly due to shading effect of pearl millet, which forced clusterbean plants towards vertical growth for better light interception. Similar observations were reported by Prajapat *et al.*, (2019) ^[9]. Foliar application of 3% panchgavya also significantly improved clusterbean plant height and recorded maximum values of 61.2 cm, 83.5 cm and 86.8 cm at 60 DAS, 90 DAS and at harvest, respectively. The enhancement in plant height might be due to improved nutrient availability and hormonal activity provided by panchgavya. Similar findings were reported by Gunasekar *et al.*, (2018) ^[5] and Chaitanya *et al.*, (2021) ^[3].

Dry Matter Accumulation

Pearl millet

Dry matter accumulation in pearl millet and clusterbean increased progressively with advancement in crop growth stages. Pearl millet + clusterbean (1:2) recorded significantly maximum dry matter accumulation of 38.3 g/plant at 60 DAS and 50.2 g/plant at harvest. This treatment increased dry matter accumulation by 6.98, 7.60, 13.2 and 21.1 per cent at 60 DAS and 5.20, 6.40, 11.6 and 20.3 per cent at harvest over pearl millet + clusterbean (2:2), pearl millet + clusterbean (1:1), pearl millet + clusterbean (2:1) and sole pearl millet, respectively. Higher dry matter accumulation under intercropping might be attributed to better utilization of growth resources such as nutrients, moisture, space and sunlight. Legume intercrops also contributed biologically fixed nitrogen, which improved overall crop growth and photosynthetic efficiency. Similar findings were reported by Prajapat *et al.*, (2015) ^[10]. Foliar application of 3% panchgavya significantly improved dry matter accumulation in pearl millet and recorded maximum dry matter of 36.2 g/plant at 60 DAS and 47.8 g/plant at harvest, which were 11.8 and 8.90 per cent higher than control, respectively. Panchgavya likely enhanced chlorophyll synthesis, nutrient uptake and photosynthetic activity, resulting in greater biomass accumulation. Similar results were observed by Ashokh *et al.*, (2020) ^[2] and Patel *et al.*, (2021) ^[7].

Clusterbean

In clusterbean, sole clusterbean recorded significantly maximum dry matter accumulation of 12.4 g/plant at 60 DAS, 21.2 g/plant at 90 DAS and 23.4 g/plant at harvest over pearl millet + clusterbean (1:2), pearl millet + clusterbean (1:1), pearl millet + clusterbean (2:2) and pearl millet + clusterbean (2:1), intercropping system respectively. Greater dry matter accumulation under sole cropping may be due to absence of interspecific competition and better availability of light, moisture and nutrients. Among liquid organic manures, 3% panchgavya significantly increased dry matter accumulation in clusterbean and recorded maximum values of 11.5 g/plant at 60 DAS, 20.0 g/plant at 90 DAS and 22.2 g/plant at harvest. The increase was 10.9, 18.5 and 11.9 per cent at 60 DAS, 90 DAS and at harvest over control, respectively. Improved nutrient supply and microbial activity through panchgavya might have

enhanced physiological efficiency and biomass production. Similar results were reported by Chaitanya *et al.*, (2021) ^[3].

Pearl millet Equivalent Yield (PEY)

Pearl millet equivalent yield (PEY) was significantly influenced by different intercropping systems and liquid organic manures. Among intercropping systems, pearl millet + clusterbean (1:2) recorded significantly highest pearl millet equivalent yield of 2910 kg/ha, which was 13.3 and 83.9 per cent higher over pearl millet + clusterbean (2:1) and sole pearl millet, respectively. However, it remained statistically at par with pearl millet + clusterbean (2:2), pearl millet + clusterbean (1:1) and sole clusterbean. Higher PEY under intercropping systems might be due to efficient utilization of growth resources and additional yield advantage obtained from clusterbean component crop. Legume-based intercropping systems are known to improve system productivity and land-use efficiency through complementary interactions between component crops. Similar findings were reported by Syafruddin and Suwardi (2020) ^[15]. Foliar application of 3% panchgavya also recorded significantly higher PEY of 2696 kg/ha over control. Enhanced equivalent yield under panchgavya treatment may be attributed to improvement in growth characters, dry matter accumulation, yield attributes and nutrient uptake, ultimately leading to higher productivity of both component crops. Similar findings were reported by Choudhary *et al.*, (2017) ^[4] and Patel *et al.*, (2021) ^[7].

Land Equivalent Ratio (LER)

The significantly highest land equivalent ratio (1.26) was obtained under pearl millet + clusterbean (2:2). This treatment gave 26 per cent more land equivalent ratio over clusterbean sole and pearl millet sole both, indicated that 26 per cent more area would be required by sole cropping systems to recover the yield of intercropping system. However, it was found at par with pearl millet + clusterbean (1:1), pearl millet + clusterbean (2:1) and pearl millet + clusterbean (1:2) intercropping system. Higher LER values are showing advantage of intercropping over sole system in terms of the use of environmental resources for plant growth. It was also indicated that higher LER was obtained only in those treatments in which intercrops (legume component) contribute more in the LER value. The high LER observed in intercropping systems is often due to the biological efficiency of the system in terms of maximizing yields/area. These findings are consistent with results reported by Yadav *et al.*, (2015) ^[16] and Arif *et al.*, (2022) ^[1].

Economics

Application of pearl millet + clusterbean (2:2) row ratio recorded significantly higher mean net returns (62923 ₹/ha) to the tune of 19.9 and 52.3 per cent over clusterbean sole and pearl millet sole, respectively. These increased net returns in this 2:2 were primarily attributed to higher seed/grain and stover/straw yields of pearl millet and clusterbean/area. Perusal of data (Table 3) showed that significantly higher B:C ratio (2.54) was recorded under application of pearl millet + clusterbean (2:2) intercropping by the magnitude of 22.1 and 49.4 over clusterbean sole and pearl millet sole treatments. The higher net returns and B:C ratio were associated with its higher grain/seed and stover/straw yield per unit of added cost. Similar results are found with Renu *et al.*, (2018) ^[11] and Arif *et al.*, (2022) ^[1].

Table 1: Plant height as influenced by various liquid organic manures in pearl millet + clusterbean intercropping system

Treatment	Plant height (cm)						
	Pearlmillet			Clusterbean			
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Intercropping System (IC)							
IC ₁ -Pearlmillet + Clusterbean (1:1)	39.0	123.8	137.0	17.4	60.7	82.5	84.6
IC ₂ -Pearlmillet + Clusterbean (2:1)	39.7	136.4	148.8	17.1	66.1	89.3	94.0
IC ₃ -Pearlmillet + Clusterbean (1:2)	38.0	113.9	129.9	16.8	55.7	79.8	82.0
IC ₄ -Pearlmillet + Clusterbean (2:2)	39.6	126.2	142.1	17.3	59.9	80.6	82.7
IC ₅ -Pearlmillet sole	41.7	147.9	163.6	-	-	-	-
IC ₆ -Clusterbean sole	-	-	-	18.1	53.3	74.2	77.5
SE _m ±	0.89	2.8	3.02	0.46	1.33	1.44	1.49
CD (P=0.05)	NS	8.3	8.91	NS	3.93	4.24	4.38
Liquid organic manures (M)							
M ₀ -Control	38.3	120.8	136.2	17.0	55.7	76.7	78.9
M ₁ -Vermiwash (10%)	40.0	133.4	147.4	17.5	60.4	82.9	86.0
M ₂ -Panchgavya (3%)	40.6	133.9	150.3	17.6	61.2	83.5	86.8
M ₃ -Cow urine (10%)	39.5	130.4	143.3	17.4	59.2	82.1	84.9
SE _m ±	0.68	1.48	1.84	0.27	0.8	0.8	0.81
CD (P=0.05)	NS	4.15	5.17	NS	2.23	2.24	2.28

Table 2: Dry matter accumulation as influenced by various liquid organic manures in pearl millet + clusterbean intercropping system

Treatment	Dry matter accumulation (g/plant)						
	Pearlmillet			Clusterbean			
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Intercropping System (IC)							
IC ₁ -Pearlmillet + Clusterbean (1:1)	6.24	35.6	47.2	2.69	11.0	19.5	21.5
IC ₂ -Pearlmillet + Clusterbean (2:1)	6.11	33.8	45.0	2.55	10.3	16.0	18.9
IC ₃ -Pearlmillet + Clusterbean (1:2)	6.48	38.3	50.2	2.62	11.4	20.2	22.2
IC ₄ -Pearlmillet + Clusterbean (2:2)	6.36	35.8	47.8	2.66	10.7	18.6	20.6
IC ₅ -Pearlmillet sole	6.58	31.6	41.8	-	-	-	-
IC ₆ -Clusterbean sole	-	-	-	2.77	12.4	21.2	23.9
SE _m ±	0.16	0.6	0.83	0.05	0.21	0.4	0.44
CD (P=0.05)	NS	1.77	2.44	NS	0.61	1.18	1.29
Liquid organic manures (M)							
M ₀ -Control	6.26	32.5	43.9	2.58	10.4	16.9	19.8
M ₁ -Vermiwash (10%)	6.39	35.9	47.2	2.68	11.4	19.9	22.0
M ₂ -Panchgavya (3%)	6.44	36.2	47.8	2.74	11.5	20.0	22.1
M ₃ -Cow urine (10%)	6.33	35.5	46.6	2.64	11.3	19.7	21.8
SE _m ±	0.07	0.32	0.44	0.04	0.17	0.21	0.22
CD (P=0.05)	NS	0.9	1.22	NS	0.46	0.58	0.62

Table 3: Pearlmillet equivalent yield (PEY), Land equivalent ratio, net returns and benefit - cost ratio as influenced by various liquid organic manures in pearl millet + clusterbean intercropping system

Treatments	PEY	LER	Net returns	B:C ratio
Intercropping System (IC)				
IC ₁ -Pearlmillet + Clusterbean (1:1)	2777	1.24	62411	2.50
IC ₂ -Pearlmillet + Clusterbean (2:1)	2569	1.24	60420	2.45
IC ₃ -Pearlmillet + Clusterbean (1:2)	2910	1.21	62074	2.49
IC ₄ -Pearlmillet + Clusterbean (2:2)	2779	1.26	62923	2.54
IC ₅ -Pearlmillet sole	1582	1.00	41326	1.70
IC ₆ -Clusterbean sole	2874	1.00	52473	2.08
SE _m ±	52	0.02	1189	0.05
CD (P=0.05)	152	0.07	3509	0.16
Liquid organic manures (M)				
M ₀ -Control	2410	-	52248	2.17
M ₁ -Vermiwash (10%)	2627	-	58067	2.30
M ₂ -Panchgavya (3%)	2697	-	60086	2.39
M ₃ -Cow urine (10%)	2594	-	57350	2.31
SE _m ±	37	-	906	0.03
CD (P=0.05)	104.9	-	2536.4	0.10

Conclusion

Based on present investigation it is found that sole pearl millet recorded significantly higher plant height of pearl millet, whereas

pearl millet + clusterbean (1:2) intercropping system registered maximum dry matter accumulation and highest pearl millet equivalent yield (2910 kg/ha). In clusterbean, pearl millet + clusterbean (2:1) intercropping system recorded higher plant height, while sole clusterbean accumulated maximum dry matter. However, pearl millet + clusterbean (2:2) intercropping system recorded significantly higher land equivalent ratio (1.26), net returns (₹62,923 /ha) and B:C ratio (2.54). Among liquid organic manures, foliar spray of 3% panchgavya significantly improved growth and productivity of both crops and recorded significantly higher plant height, dry matter accumulation, pearl millet equivalent yield (2697 kg/ha), net returns (₹60,086 /ha) and B:C ratio (2.39), remaining statistically at par with 10% vermiwash.

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