Response of Intercropping of Pearl Millet [*Pennisetum glaucum* (L.)]+ Green gram [*Vigna Radiata*] on Yield and Economics under Sandy Loam soils of Rajasthan, India

Abstract

The existing experiment was conducted at MJRPU, Jaipur during 2021-22 season. Nowadays fertility of soil was decreasing day by day so the present investigation was conducted to assess the fertility as well as other effects on growth and yield of both the crops. The experiment was conducted using randomized block design with 10 treatment combination replicated thrice. The treatments were as T_1-Pearl millet (drilled) + Green gram (1:1) 45 cm, T_2-Pearl millet (drilled) + Green gram (2:1) 45 cm, T_3-Pearl millet (drilled) + Green gram (1:2) 30 cm, T_4-Pearl millet (drilled) + Green gram (2:2) 30 cm, T_5-Pearl millet (T. P.) + Green gram (1:1) 45 cm, T_6-Pearl millet (T. P.) + Green gram (2:1) 45 cm, T_7-Pearl millet (T. P.) + Green gram (1:2) 30 cm, T_8-Pearl millet (T. P.) + Green gram (2:2) 30 cm, T_9-Pearl millet sole (drilled) 45 cm and T_{10}-Pearl millet sole (T. P.) 45 cm. From the current examination it can be concluded that higher growth parameters, growth, grain yield, straw yield, and net realization of summer pearl millet could be achieved either sole pearl millet crop when transplanted at 45 cm or 30 cm, or when it is transplanted as an intercrop with green gram at a row ratio of 2:1 of 45 cm or sole pearl millet crop when sown by drill method at 45 cm row spacing. The soil available nitrogen also found non-significant at harvest.

Keywords: Dry matter accumulation, benefit and cost ratio

Introduction

Pearl millet, scientifically known as *Pennisetum glaucum* (L.), stands as a vital cereal crop prominently cultivated in arid and semi-arid regions globally. In India, it holds the fourth position among major food grain crops, trailing behind rice, wheat, and sorghum (Fetene et al., 2011). Popularly referred to as 'bajra' or 'bajri,' it serves as a crucial staple food, especially in states like Gujarat, Rajasthan, Madhya Pradesh, Maharashtra, and Uttar Pradesh. Its cultivation spans both rainy (kharif) and summer seasons in regions like Rajasthan, although challenges in timely sowing and yield are encountered when grown in rotation with tobacco, mustard, or wheat (Chapke et al., 2018). With a history dating back to prehistoric times in Africa and Asia, pearl millet covers an extensive area of 6.93 million hectares in India, yielding an average production of 8.61 million tons. The cultivation zones are categorized based on soil types and rainfall patterns, with the northwestern, northern, central, and peninsular regions each having distinct characteristics (Verma et al., 2016). Intercropping strategies, particularly with legumes like green gram, are explored not only for economic benefits but also for their potential to enhance soil properties amidst a focus on addressing pulse scarcity in the country (Dwivedi et al., 2016).

Intercropping is an agricultural practice where two or more crops are cultivated simultaneously in the same field. This strategy offers several benefits, including efficient land utilization, improved resource use, and risk reduction (Lithourgidis et al., 2011). By planting crops with different growth patterns or nutrient needs, intercropping optimizes space and promotes biodiversity. This practice often helps in weed and pest control as different crops may act as natural deterrents to specific pests or diseases. Additionally, intercropping can enhance soil fertility by diversifying root structures and nutrient uptake. Farmers may choose complementary crops that don't compete for the same resources, such as one with deep roots and another with shallow roots. Overall, intercropping is a sustainable and holistic approach that contributes to increased productivity, resilience, and environmental sustainability in agriculture (Raseduzzaman and Jensen, 2017.

Intercropping between pearl millet (Pennisetum glaucum) and green gram (Vigna radiata) is a strategic agricultural approach that combines the benefits of both crops. Pearl millet, a major cereal crop, and green gram, a leguminous pulse, complement each other effectively in terms of growth patterns and nutrient requirements (Rani et al., 2017). Pearl millet, with its tall stature, provides a supportive framework for the shorter green gram plants, optimizing sunlight utilization. Green gram, being a legume, has the ability to fix atmospheric nitrogen, enriching the soil with this essential nutrient (Layek et al., 2018). This symbiotic relationship not only enhances overall crop yield but also contributes to soil fertility. Furthermore, intercropping helps in efficient use of available resources, reduces the risk of pests and diseases, and offers economic advantages to farmers. The combination of pearl millet and green gram exemplifies a sustainable and mutually beneficial intercropping system that addresses both food and soil health concerns (Behera and France 2016).

Material and methods

The experiment was carried out at Research farm of MJRP College of Agriculture & Research, Achrol, Jaipur (MJRPU, Jaipur). Geographically is situated in Rajasthan at Latitude and longitude coordinates of 26.922070, 75.778885 respectively and about 36 km away from Jaipur railway station. This region falls under agro-climatic arid of Rajasthan. The mean meteorological weather parameters were given in the following fig.1.

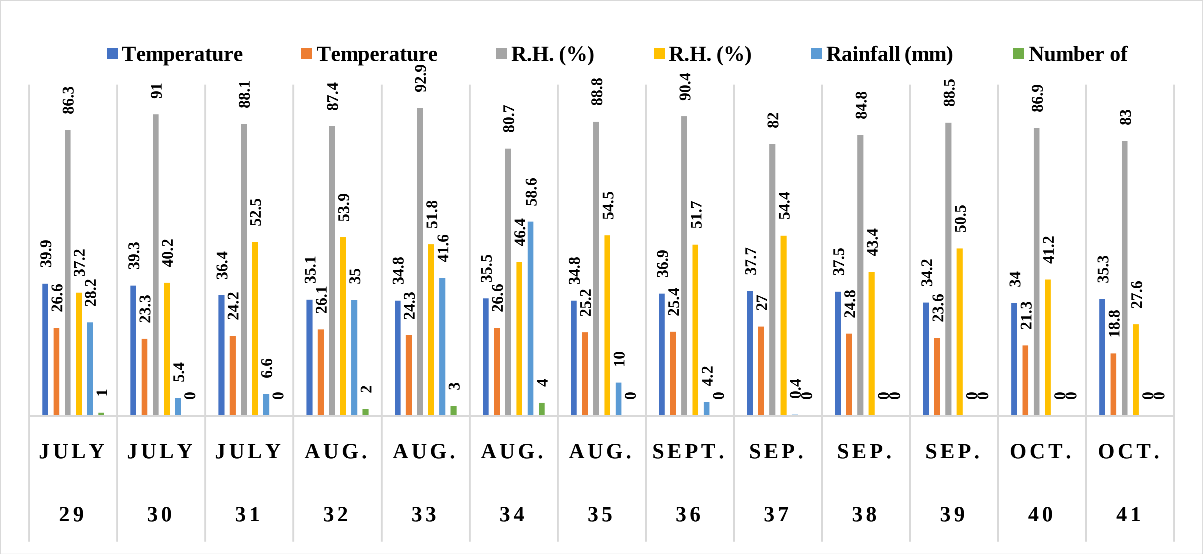

Fig.1: Mean meteorological weather parameters

The present experiment was carried out in randomized block design with 10 treatments replicated thrice of different intercropping and spacing. The existing 10 treatments were as Pearl millet (drilled) + Green gram (1:1) 45 cm (T_1), Pearl millet (drilled) + Green gram (2:1) 45 cm (T_2), Pearl millet (drilled) + Green gram (1:2) 30 cm (T_3), Pearl millet (drilled) + Green gram (2:2) 30 cm (T_4), Pearl millet (T. P.) + Green gram (1:1) 45 cm (T_5), Pearl millet (T. P.) + Green gram (2:1) 45 cm (T_6),Pearl millet (T. P.) + Green gram (1:2) 30 cm (T_7), Pearl millet (T. P.) + Green gram (2:2) 30 cm (T_8), Pearl millet sole (drilled) 45 cm (T_9), Pearl millet sole (T. P.) 45 cm (T_{10}). The RHB- 171 variety was taken for conducting the experiment. The growth parameters were measured timely. The statistical analysis of the data of various characters studied in the investigation was carried out through the procedure appropriate to the design of the experiment as described by Panse and Sukhate (1997). The critical differences for comparing treatment means were worked out at 5 per cent level of significance. The co-efficient of variation (C.V. %) was also worked out.

Results and Discussion

Dry Matter Accumulation Plant^{-1} (g)

Data on average dry matter accumulation plant^{-1} as affected by intercropping system with different row ratios under varying establishment methods of pearl millet are presented in Table 1.

Pearl millet plant^{-1} dry matter accumulation (g) at harvest

The mean data on dry matter accumulation plant^{-1} (Table 1) indicated significant difference due to crop establishment methods of summer pearl millet. T_7 recorded significantly higher matter weight accumulation (90.70 g) but it was at par with T_5, T_8, T_{10}, T_6 and T_9. Significantly lower dry matter accumulation (68.43 g) was observed in T_2 (Pearl millet sole drilled with green gram 2:1 row ratio at 45 cm).Transplanting methods recorded significantly the higher dry matter accumulation plant^{-1} as compared to rest of the treatments.

Green gram dry weight accumulation plant^{-1} (g)

A perusal of data given in Table 1 indicated that dry weight accumulation of green gram plant^{-1} was non-significantly influenced due to intercropping system with different row ratios under varying establishment methods of summer pearl millet.

Grain Yield of Pearl millet (kg ha^{-1})

Green gram test weight (g)

From the data given in fig. 2. it is revealed that intercropping system with different row ratios under varying establishment methods had non-significant effect on test weight of green gram.The grain yield as affected by intercropping system with different row ratios under varying establishment methods are presented in fig. 2. Data in fig. 2, showed that grain yield of pearl millet was significantly higher in treatment T_{10} (sole transplanted pearl millet 45 cm) (4222 kg ha^{-1}), being at par with treatment T_6 [pearl millet T. P. + green gram (2:1) 45 cm] (3861 kg ha^{-1}) and T_9 (pearl millet sole drilled 45 cm) (3833 kg ha^{-1}). While, the grain yield (2708 kg ha^{-1}) of pearl millet was significantly lower when drilled pearl millet crop was intercropped (1:2 row ratio 30 cm) with green gram. Significantly higher grain yield was recorded by transplanted pearl millet than rest of the sole drilled and intercropping treatments. Significantly higher grain yields were recorded by sole pearl millet than rest of the intercropping treatments. This could be attributed to higher and optimum plant densities in sole cropping system. The lower grain yield was noticed under Treatment T_3 (pearl millet with green gram at 1:2 row ratio intercropping system).

Straw Yield of Pearl millet (kg ha^{-1})

The data on straw yield of pearl millet as influenced by intercropping system with different row ratios under varying establishment methods are presented in fig. 2. A perusal of data (fig.

2) revealed that straw yield was significantly affected due to treatment effects. The treatment T_{10} (sole transplanted pearl millet 45 cm) (7986 kg ha^{-1}) produced significantly higher straw yield. followed by treatment T_6 (7778 kg ha^{-1}), T_9 (7361 kg ha^{-1}). Significantly the lowest straw yield (5555 kg ha^{-1}) was registered under treatment T_3 (drilled method pearl millet crop was intercropped at 1:2 row ratio 30 cm with green gram).

Seed Yield of Green gram (kg ha^{-1})

The data pertaining to seed yield of green gram as affected by intercropping system with different row ratios under varying establishment methods are presented in fig. 2. The data (fig. 2) indicated that the seed yield of green gram was significantly affected due to intercropping system with different row ratios under varying establishment methods. T_7 (pearl millet T.P + green gram 1:2 row ratio 30 cm) (159 kg ha^{-1}) recorded significantly higher seed yield and it was remained at par with T_3 (pearl millet drilled + green gram with 1:2 row ratio 30 cm) (158 kg ha^{-1}) and T_4 (142 kg ha^{-1}). Significantly the lowest seed yield of green gram was observed in treatment T_2 (Pearl millet drilled + green gram 2:1 row ratio at 45 cm).

Haulm Yield (kg ha^{-1})

The mean data in respect on haulm yield as influenced by intercropping system with different row ratios under varying establishment methods are presented in fig. 2. The data indicated that the seed yield was significantly affected due to intercropping system with different row ratios under varying establishment methods of summer pearl millet. T_7 [pearl millet T.P + green gram (1:2 row ratio) with 30 cm] recorded significantly higher haulm yield (590 kg ha^{-1}) and it was remained at par with T_3 [pearl millet drilled + green gram (30 cm)] (583 kg ha^{-1}). Significantly low haulm yield (314 kg ha^{-1}) of green gram was observed in treatment T_2 [pearl millet drilled + green gram (2:1 row ratio) with 45cm spacing].

Economics

The details of income, cost of cultivation and CBR for individual treatment are worked out and presented in Table 2. The cost of cultivation pearl millet and green gram details of cost incurred in treatment. There was an appreciable increase in net realization due to intercropping system with varying establishment methods as show in Table 2. Higher net returns were found in treatment T_{10} (pearl millet sole transplanted at 45 cm) (50201 ₹ ha^{-1}) with CBR (1: 3:38), equal but while highest CBR (1:3.45) was noticed in T_6 (pearl millet T. P. + green gram 2:1 row ratio at 45 cm) and T_2 low net realization and CBR fond in T Pearl millet sole (T. P.) 45 cm (T_{10}).

Table 1: Effect of various treatments on growth parameters of pearl millet and green gram

Treatments	Dry matter accumulation plant^{-1} (g)	
	Pearl millet	Green gram
T_1	71.12	7.60
T_2	68.43	7.55
T_3	78.02	7.45
T_4	76.10	7.53
T_5	89.78	7.78
T_6	87.53	7.63
T_7	90.70	7.35
T_8	87.90	7.50
T_9	83.85	-
T_{10}	87.58	-

SEm±	**4.27**	**0.24**
CD (*P*=0.05%)	**12.30**	**NS**

Discussion

At 30 DAS treatment T_7 (Pearl millet T.P + green gram) 1:2 row ratio with 30 cm spacing registered higher plant height (77.63 cm). At 60 DAS significantly higher plant height was obtained with Pearl millet (T. P.) + Green gram (1:2) 30 cm (T_7). At harvest treatment T_9 (Pearl millet drilled sole) registered higher plant height (193.5 cm) but it was at par with treatment T_2, T_4, T_1 and T_3. Plant height of pearl millet at maturity was statistically higher in sole drilled pearl millet as compared to pearl millet with intercrops (Table 2), which might be attributed to higher cell elongation due to auxin accumulation in plant (Choudhary, 2012) Moreover, light availability was comparatively lesser due to higher plant densities under sole crop. In sole cropping of pearl millet, plant height increased due to competition for sunlight among the plants. The shorter plants of pearl millet were found when intercropped at 1:2 row ratio with pearl millet + green gram. This was due to interspecies and cooperative interaction of intercrops with pearl millet for non–renewable resources like water, nutrients and light. These results corroborated with the finding of Baldevram*et al*. (2005) and Yadav *et al*. (2014). Among all treatments, Transplanting gave significantly the lowest plant height at harvest which might be due to greater transfer of photosynthates from vegetative source to reproductive sink. The results are in conformity with those reported by Upadhyay et al. (2001), Patel and Patel, 2002), Rathore and Gautam (2003) and Lakhani *et al*. (2014).

The significantly higher dry matter accumulation was obtained with T_7 recorded significantly higher matter weight accumulation (90.70 g) but it was at par with T_5, T_8, T_{10}, T_6 and T_9. This increased in dry matter accumulation might be due to higher number of tillers metre^{-1} row length (Table 2) under transplanting method. This result is confirmed with the result obtained by Patil *et al*. (2014). Better growth of pearl millet in intercropping system might be due to the ability of intercrops to enrich the soil through fixation of free nitrogen from the atmosphere. Intercrops being legume crops could release nitrogen during growth and so benefited to companion crop. There are two aspects of this (1) the excretions of nitrogen from the intercrops are simultaneously used by the companion graminaceous crop at later stages and (2) in addition to this, due to short duration of intercrops, it did not compete for environmental factors, like sun light and space which show greater compatibilities with pearl millet in different intercropping systems. The significant increase in dry matter accumulation at successive crop growth stage seems to be on account of production of higher tillers plant-1 which might have led to greater absorption and utilization of radiant energy resulting in higher accumulation of photosynthates and finally dry matter plant^{-1}. These results are in close conformity with those of Bangali (1987), Yadav and Jat, 2005 and Prajapat *et al*. (2015).

Data in fig. 2 showed that grain yield of pearl millet was significantly higher in treatment T_{10} (sole transplanted pearl millet 45 cm) (4222 kg ha^{-1}), being at par with treatment T_6 [pearl millet T. P. + green gram (2:1) 45 cm] (3861 kg ha^{-1}) and T_9 (pearl millet sole drilled 45 cm) (3833 kg ha^{-1}). The effect of transplanting on the grain yield can be explained on the basis that transplanting tended to produced more vegetative growth resulting from efficient utilization of nutrients, water, radiation and increased metabolic activities followed by increased translocation of photosynthesis might have led to significant increase in grain yield. The present findings are supported from the results reported by Tomer at al. (1980), Bhaskar (1986) *et al*. (1998), Upadhyay *et al*. (2001) and Patel and Patel (2002). This might be due to lower plant densities of pearl millet and also higher competition offered by intercrops for natural resources like space, plant nutrient, moisture and incoming sun radition. The results are corroborating with the finding of Baldevram*et al*. (2005), Kumar et al. (2006), Choudhary *et al*. (2012) and Patel and Patel (2012).

The treatment T_{10} (sole transplanted pearl millet 45 cm) (7986 kg ha^{-1}) produced significantly higher straw yield. followed by treatment T_6 (7778 kg ha^{-1}), T_9 (7361 kg ha^{-1}). This might be due to lower plant densities of pearl millet and also higher competition offered by intercrops for natural resources like space, plant nutrient, moisture and incoming sun radiation. The result is corroborating with the finding of Baldevram*et al*. (2005), Kumar *et al*. (2006), Choudhary *et al*. (2012) and Patel and Patel (2012).

The data (fig. 2) indicated that the seed yield of green gram was significantly affected due to intercropping system with different row ratios under varying establishment methods. T_7 (pearl millet T.P + green gram 1:2 row ratio 30 cm) (159 kg ha^{-1}) recorded significantly higher seed yield and it was remained at par with T_3 (pearl millet drilled + green gram with

1:2 row ratio 30 cm) (158 kg ha^{-1}) and T_4 (142 kg ha^{-1}). This variation was due to decreased in plant density under pearl millet + green gram (2:1) when grown as intercrop, higher competition among pearl millet and intercrop for natural resources like soil moisture, plant nutrient, space and sunlight for photosynthesis rate resulting lower accumulation of dry matter. These results are closely followed by Choudhary (2012), Tomar and Saini (1979) and Variya *et al*. (2012).

T_7 [pearl millet T.P + green gram (1:2 row ratio) with 30 cm] recorded significantly higher haulm yield (590 kg ha^{-1}) and it was remained at par with T_3 [pearl millet drilled + green gram (30 cm)] (583 kg ha^{-1}). Such variation could be ascribed due to decreased in plant densities when grown as intercrops with pearl millet and higher competition among pearl millet and intercrops for natural resources like soil moisture, plant nutrient, space and sunlight which are responsible for higher photosynthesis rate resulting lower accumulation of dry matter per plant in comparison to sole crop. These results are supported by Bhardoria*et al*. (1992), Kumar *et al*. (2006), Choudhary (2012), Patel *et al*. (2013) and Patil *et al*. (2014).

Conclusion

From the current examination it can be concluded that higher growth parameters, growth, grain yield, straw yield, and net realization of summer pearl millet could be achieved either sole pearl millet crop when transplanted at 45 cm or 30 cm, or when it is transplanted as an intercrop with green gram at a row ratio of 2:1 of 45 cm or sole pearl millet crop when sown by drill method at 45 cm row spacing. The soil available nitrogen also found non-significant at harvest.

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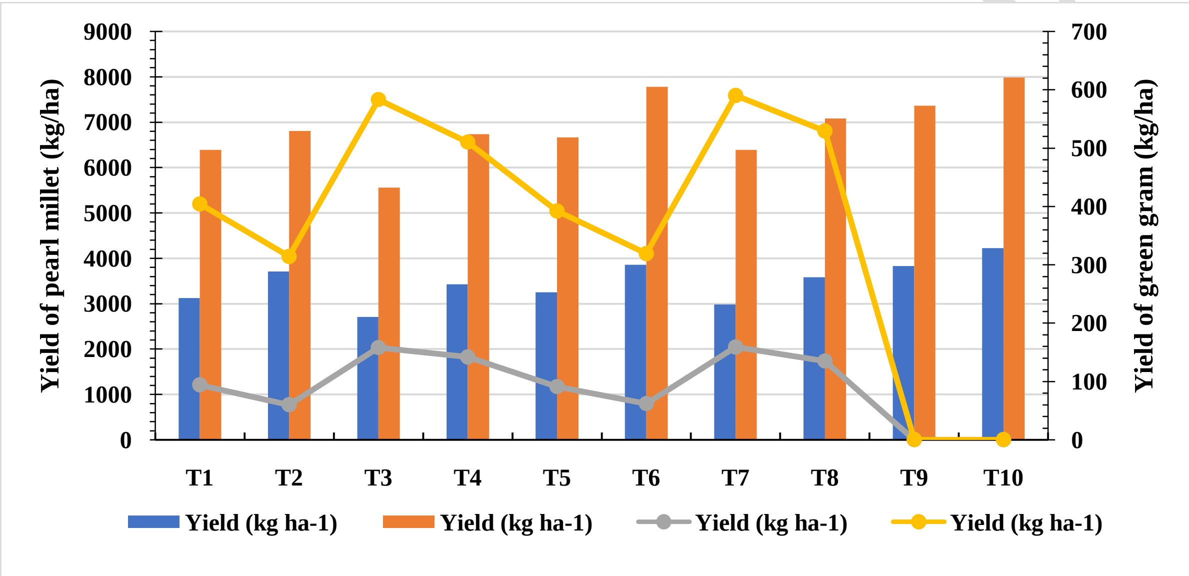

Fig. 2: Effect of different treatments on yield of pearl millet and green gram

Table 2: Effect of various treatments on economics of pearl millet and green gram

Treatments	**Gross realization (₹ ha^{-1})**	**Total expenditure (₹ ha^{-1})**	**Net return (₹ ha^{-1})**	**CBR**
T_1	58772	1830	40242	1:3.17
T_2	66054	19153	46901	1:3.45
T_3	55242	18329	36913	1:3.01

T_4	66321	19867	46454	1:3.34
T_5	60751	19485	41266	1:3.12
T_6	69431	20107	49324	1:3.45
T_7	60309	19285	41024	1:3.13
T_8	6861	20853	74828	1:3.30
T_9	64856	20159	44697	1:3.22
T_{10}	71316	21115	50201	1:3.88