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EFFECT OF PEARL MILLET (*PENNISETUM GLAUCUM* L.) - PULSES INTERCROPPING SYSTEM AND NUTRIENT MANAGEMENT ON QUALITY OF PEARL MILLET

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ABSTRACT

A field experiment was conducted at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) to study the effect of pearl millet (*Pennisetum glaucum* L.) - pulses intercropping system and nutrient management on growth and yield of pearl millet during summer season of the years 2021 and 2022. The experiment was laid out in a split plot design consisting 24 treatment combinations replicated thrice. The main plot treatments comprised of four intercropping system *viz*., sole pearl millet (I_1), pearl millet + greengram (I_2), pearl millet + blackgram (I_3), pearl millet + cowpea (I_4) and six nutrient management practices in sub plot *viz*. control (F_1), 100% RDF to pearl millet through inorganic fertilizer (F_2), 5 t/ha FYM + 100% RDF through inorganic fertilizer (F_3), 5 t/ha FYM + 100% RDF through inorganic fertilizer on base of STV (F_4), 25% RDN through FYM + 75% RDF through inorganic fertilizer (F_5) and 50% RDN through FYM + 50% RDF through inorganic fertilizer (F_6). Among main plot effect, significantly higher grain and straw yields of pearl millet were noted in sole pearl millet (I_1) during both the years of investigation as well as in pooled analysis while, pearl millet equivalent yield, protein content, protein yield and nutrient content (N in seed and straw) were significantly higher in pearl millet + greengram (I_2) intercropping system. In case of sub plot nutrient management practices, significantly higher values of grain and straw yields as well as pearl millet equivalent yield, protein content, protein yield and nutrient content (N and P in seed and straw) were recorded in F_4 (5 t/ha FYM + RDF through inorganic fertilizer on base of STV), which remained statistically at par with treatment F_3 (5 t/ha FYM + 100% RDF through inorganic fertilizer) treatment.

Key words : Intercropping system, Nutrient management, Pearl millet, Pulses, Yield, Quality.

Introduction

Indian economy is one of the fastest growing economies and is predominantly agrarian based. As our country races towards becoming one of the largest economies in the world, it must ensure that agriculture its primary sector, should achieves its full-fledged growth. In India, rainfed agro-ecosystem the so-called grey patches untouched by green revolution occupies a very important position in the Indian agriculture. Approximately 56% of the total cultivated area in India falls under rainfed agriculture. The importance of the rainfed agriculture can be gauged from the fact that it contributes to 40% of the country's food production; accounts for much of the national area under coarse cereals (85%), pulses (83%), oilseeds (70%) and cotton (65%) as well as supports 60% of the total livestock populations (Venkateswarlu and Prasad, 2012). Therefore, the developmental needs of the rainfed regions would be of foremost importance in future too.

Pearl millet (*Pennisetum glaucum* L.) is commonly known as Bajra, Indian millet and Cattail millet in India. It is the fourth most important food grain crop after rice,

wheat, sorghum and among the millets; it comes next to sorghum in area and production. Besides being a staple diet of about 10% population of our country, it is an important fodder crop also. The nutritive value of pearl millet is high and have higher amount of fat content as compared to other cereals and imparts substantial energy to the body with good digestibility (Sharma and Burark, 2015). It is one of the most important rainfed crops, being inherent drought-escaping mechanism and adaption to drier and low fertile conditions, it occupies a prime place in dry land agriculture and contributing significantly to country's food security. But typically pearl millet cultivated as a mono crop in arid and semi-arid region of the state that increased chance of low production as well as limited availability of land resources and declining soil fertility has raised concerns about ability of agriculture to sustain the increasing demand of the population. To counter the demand, we have to look for ways which enhance the use of currently available resources than in the past.

Intercropping is one promising practice which is effective to augment the total productivity per unit area of the land per unit time by growing more than one crop in the same field with an objective of better utilization of environmental resources. The basic concept of intercropping involves growing together two or more crops with the assumption that two crops can exploit the environment better than one and ultimately produce higher yield (Reddy *et al*., 2013). Cereal-pulses intercropping have attracted the attention of agronomists, possibly as a result of the established and theoretical advantages of intercropping systems. Intercropping with pulses is a practice in which N fixed by latter enhances the qualitative and quantitative traits of the former to finally reach food security and sustainability. Pulses such as greengram, blackgram and cowpea are known to fix the atmospheric nitrogen with the help of *Rhizobium* bacteria and it supplies the cereal crop with the required nitrogen. Nutrient management is one of the important cost effective factors known to augment the crop production. Hence, inclusion of pulses in any intercropping system has becomes imperative with the overall view of maintaining soil fertility and for economizing fertilizer use. Keeping the foregoing circumstances in mind present study is conducted to evaluate the effect of intercropping pulses *i.e*., greengram, blackgram and cowpea with pearl millet and different nutrient management practices on the growth and yield of the pearl millet.

Materials and Methods

Experimental site

The field experiment was carried out during summer season of both the years 2021 and 2022 on plot E-18 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). Geographically, situated at 20^0 57' North latitude, 72^0 54' East longitudes with an elevation of 10 meters of above the mean sea level. The place is located 12 km away in the East from the great historical place "Dandi" on the Arabian seashore. Before commencement of experiment pre-planting, composite soil samples were collected from the experimental site at 0-15 cm depth and the composite sample was prepared and analyzed for physical and chemical characteristics. The soil texture of the experimental site was clayey in nature having 13.09% sand, 24.58% silt and 62.33% clay with medium depth (50 cm). The soil was slightly alkaline in nature with pH 8.10 and electrical conductivity of 0.42 dS/m. The initial nutrient status in soil was determined by using the standard procedure and result indicated that the experimental site was low in organic carbon (0.39%) and available nitrogen (196.23 kg/ha), while medium in available phosphorus (38.85 kg/ha) and high in potassium (290.20 kg/ha).

Treatment details

The experimental treatments were consisted of two factors in split plot design. Main plot had four treatments of intercropping system *viz*., sole pearl millet (I_1), pearl millet + greengram (I_2), pearl millet + blackgram (I_3) and pearl millet + cowpea (I_4). While sub plot was consisting of six nutrient management practices *viz*., Control (F_1), 100% RDF to pearl millet through inorganic fertilizer (F_2), 5 t/ha FYM + 100% RDF through inorganic fertilizer (F_3), 5 t/ha FYM + 100% RDF through inorganic fertilizer on base of STV (F_4), 25% RDN through FYM + 75% RDF through inorganic fertilizer (F_5) and 50% RDN through FYM + 50% RDF through inorganic fertilizer (F_6) with three replications. The pearl millet variety GHB 1231, greengram variety GM 6, cowpea variety GC 6 and blackgram variety GU 3 were used as a test varieties. Pearl millet was sown in paired rows at 30 cm keeping 60 cm distance between 2 pairs to adjust 1 row of intercrop. Fertilizer application was done as per treatment to only pearl millet crops (RDF is 80:40:00 kg NPK/ha) and RDF to pulses crop base on area (RDF is 20:40:00 kg NPK/ha). All the soil chemical analysis done by as the standard analytical procedures.

Methodology

Grain yield (kg/ha) : Ear heads from all the plants of each net plot were harvested separately and allowed to sun drying for about five days. After complete drying of ear heads, the grains were separated from the ear heads with the help of tractor threshing. The produce

obtained in this way was cleaned and weighed and finally converted in hectare basis.

Straw yield (kg/ha) : After harvesting and nipping of ear heads, the fodder from each net plot was allowed to sundry separately for few days and the weight of sun dried fodder was recorded with the help of spring balance and converted on hectare basis.

Pearl millet equivalent yield (kg/ha) : The pearl millet equivalent yield (PEY) was calculated on the basis of formula given below:

PEY (kg/ha) = {Yp (kg/ha)} + {Y_I (kg/ha) × P_I (` /kg)} / {$P_P$ (` /kg)}

Where, $\mathbf{Y_P}$**:** Grain yield of pearl millet (kg/ha), $\mathbf{Y_I}$**:** Grain yield of intercrop (kg/ha)

$\mathbf{P_I}$**:** Price of intercrop (` /kg) $\mathbf{P_P}$**:** Price of pearl millet (` /kg)

Protein content in grain (%) : Representative samples of grains were taken from each treatment of each replication and dried in oven at 65 ± 5^{0}C temperature for 24 hours and powdered by mechanical grinder then the nitrogen content in grain was determined using modified Kjeldhal's method (Jackson, 1973). Protein content (%) was calculated by multiplying the percentage of nitrogen content with the factor 6.25 (A.O.A.C., 1990).

Protein yield (kg/ha) : Protein yield of pearl millet was worked out by using following formula:

Protein yield (kg/ha) = {Protein content in grain (%) × Grain yield (kg/ha)}/100

Nutrient content (%) : Representative samples of plants were taken from each net plot for chemical analysis. They were oven dried at 70°C for 24 hours and powdered in a mechanical grinder for the estimation of N, P and K content by following standard methods. Estimation of total nitrogen was done by modified Kjeldhal's method, phosphorus by Vanadomolybdo phosphoric acid yellow colour method and potassium by Flame photometer method as described by Jackson (1973).

Statistical analysis : Analysis of variance for split plot design and significance of variance was tested by f-test. Critical difference for examining treatment means for their significance was calculated at 5% significance. Pooled analysis of two years was worked out as per the procedure suggested by Panse and Sukhatme (1967). Bartlett's test was applied to examine the homogeneity of variance due to error. The variance obtained due to season × treatment components were tested against joint 54 estimate of error variance with an objective to find out whether season × treatment interaction exist or otherwise.

Results and Discussion

Effect of Intercropping System

Yield : Grain and straw yield of pearl millet were significantly influenced by the intercropping system. Sole pearl millet (I_1), which was statistically at par with pearl millet + greengram (I_2) and pearl millet + blackgram (I_3) showed significantly higher grain and straw yield of pearl millet. The higher yield in sole stands of pearl millet over intercrop might be due to limited disturbance of the habitat and interactional competition in the sole cropping environment. It is reasonable to suggest that, two species of contrasting habit with respect to branching, leaf distribution, height, root distribution, mineral uptake or other morphological or physiological characters, will together be able to exploit the total environment more effectively over monoculture and thereby give increased overall yield.

Whereas, it is interesting to note that pearl millet + greengram (I_2) intercropping system recorded significantly higher pearl millet equivalent yield among the systems which was approximately, 12, 29 and 80 per cent higher over pearl millet + blackgram, pearl millet + cowpea and sole pearl millet, respectively due to better utilization of resources and complimentary interaction between components crops as well as extra yield and high market price of greengram. These findings are in contrast with the results of Baldev *et al*. (2005) and Mukta *et al*. (2005). There is non-significant effect of intercropping system on harvest index of pearl millet.

Quality : Greengram intercropped with pearl millet (I_2) recorded significantly higher values of protein content in grain of pearl millet as well as protein yield which were remained at par with pearl millet + blackgram (I_3) and pearl millet + cowpea (I_4) intercropping systems. Here, intercropping of pulses crop with pearl millet found more superior than sole pearl millet planting with respected to protein content might be due to the fact that pulses crops establish atmospheric nitrogen in to the soil and increase the soil fertility, which can be used by the component crop in the intercrop, which might be give the complementary effect to increase the protein content in pearl millet. The findings are in close agreement with those obtained by Desai *et al*. (2014).

Nitrogen content in grain and straw (%) : The data revealed that intercropping systems significantly influenced the nitrogen content in pearl millet grain and straw. Among the different intercropping systems examined, significantly higher nitrogen content in grain and straw was observed in I_2 (pearl millet + greengram) but it remained at par with treatments I_3 (pearl millet +

Table 1 : Effect of intercropping system and nutrient management treatments on yield of pearl millet crop (pooled data).

Treatments	Pearl millet yield		Intercrop yield		Pearl millet equivalent yield (kg/ha)
	Grain	Straw	Grain	Haulm	
I) Main plot treatment (Intercropping system)					
I_1: Sole pearl millet	2562	5551	-	-	2562
I_2: Pearl millet + greengram	2502	5485	532	819	4603
I_3: Pearl millet + blackgram	2461	5391	438	743	4076
I_4: Pearl millet + cowpea	2258	4878	396	796	3510
SEm ±	36	84	-	-	56
CD (P ≤ 0.05)	111	259	-	-	174
CV (%)	8.85	9.46	-	-	9.19
F) Sub plot treatment (Nutrient management)					
F_1: No fertilizer	1839	3933	194	469	2374
F_2: 100% RDF to pearl millet through inorganic fertilizer	2387	5110	407	698	3498
F_3: 5 t/ha FYM + 100% RDF through inorganic fertilizer	2767	6196	622	975	4458
F_4: 5 t/ha FYM + RDF through inorganic fertilizer on base of STV	2776	6232	629	994	4486
F_5: 25% RDN through FYM + 75% RDF through inorganic fertilizer	2524	5393	450	826	3752
F_6: 50% RDN through FYM + 50% RDF through inorganic fertilizer	2382	5093	430	755	3558
SEm ±	35	78	-	-	49
CD (P ≤ 0.05)	99	219	-	-	137
CV (%)	7.04	7.14	-	-	6.48
Interaction effect (I × F)					
SEm ±	70	155	-	-	97
CD (P ≤ 0.05)	198	437	-	-	274
Significant interaction with years	NS	NS	-	-	NS

blackgram) and I_4 (pearl millet + cowpea). Higher nitrogen content in grain and straw of pearl millet associated with intercropping of pulses might be due to more availability of nitrogen thereby more uptake and concentration of nitrogen in tissue because of legume crops as intercrop have capacity to fix atmospheric nitrogen in soil and nutrient sparing capacity of legume to cereal component. Another reason for improvement in nitrogen content of pearl millet grown with pulses may be attributed to "mutual avoidance" which implies that the roots tend to avoid the areas that have already been depleted of resources by an associated crop. Pearl millet and pulses differed in growth habits and duration. Thus the component crops have their peak demands for nutrients at different stages of growth; a temporal effect may ensure that the demand does not overlap. The findings are in accordance with Dadhich and Gupta (2005) as well as Tetarwal and Rana (2006).

Phosphorus content in grain and straw (%) : Scrutiny of data indicated that the response of intercropping system treatments on phosphorus content in grain and straw of pearl millet was found non-significant. Numerically higher phosphorus content in grain and straw of pearl millet was observed in treatment I_2 (pearl millet + greengram) intercropping system. While, the treatment I_1 (sole pearl millet) resulted in lower phosphorus content in grain and straw of pearl millet.

Potassium content in grain and straw (%) : An examination of data showed that all the treatments of intercropping system studied in this experiment did not have any significant effect on potassium content in grain and straw of pearl millet. Among the intercropping system, greengram intercropped with pearl millet (I_2) resulted in numerically higher values of potassium content in grain and straw of pearl millet during both the years and in pooled data.

Table 2 : Effect of intercropping system and nutrient management treatments on protein content, protein yield and nutrient content of pearl millet crop (pooled data).

Treatments	Protein Content (%)	Protein Yield (kg/ha)	N Content (%)		P Content (%)		K Content (%)	
			Grain	Straw	Grain	Straw	Grain	Straw
I) Main plot treatment (Intercropping system)								
I_1: Sole pearl millet	10.20	264.8	1.632	0.353	0.302	0.108	0.649	0.867
I_2: Pearl millet + greengram	11.57	291.6	1.851	0.405	0.315	0.110	0.671	0.898
I_3: Pearl millet + blackgram	11.34	281.0	1.814	0.385	0.311	0.108	0.662	0.882
I_4: Pearl millet + cowpea	11.19	256.3	1.790	0.385	0.311	0.110	0.668	0.886
SEm ±	0.19	4.84	0.031	0.007	0.005	0.002	0.009	0.015
CD (P ≤ 0.05)	0.60	14.92	0.095	0.020	NS	NS	NS	NS
CV (%)	10.47	10.62	10.46	10.41	10.44	9.58	8.05	10.01
F) Sub plot treatment (Nutrient management)								
F_1: No fertilizer	9.26	169.7	1.482	0.315	0.280	0.091	0.641	0.856
F_2: 100% RDF to pearl millet through inorganic fertilizer	10.88	258.9	1.740	0.372	0.304	0.106	0.654	0.863
F_3: 5 t/ha FYM + 100% RDF through inorganic fertilizer	11.95	330.5	1.912	0.413	0.320	0.117	0.673	0.898
F_4: 5 t/ha FYM + RDF through inorganic fertilizer on base of STV	12.08	335.7	1.933	0.420	0.326	0.120	0.676	0.906
F_5: 25% RDN through FYM + 75% RDF through inorganic fertilizer	11.29	284.6	1.806	0.394	0.313	0.108	0.662	0.884
F_6: 50% RDN through FYM + 50% RDF through inorganic fertilizer	10.97	261.2	1.756	0.376	0.315	0.112	0.668	0.892
SEm ±	0.16	5.59	0.025	0.006	0.005	0.002	0.010	0.016
CD (P ≤ 0.05)	0.44	15.74	0.071	0.018	0.013	0.005	NS	NS
CV (%)	7.00	10.02	6.99	8.17	7.53	8.30	7.67	8.97
Interaction effect (I × F)								
SEm ±	0.32	11.19	0.051	0.013	0.010	0.004	0.021	0.032
CD (P ≤ 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Significant interaction with years	NS	NS	NS	NS	NS	NS	NS	NS

Table 3 : Interaction effect of intercropping system and nutrient management on yield of pearl millet.

Treatment	Grain yield (kg/ha)				Straw yield (kg/ha)				PEY (kg/ha)			
F) Nutrient management	I) Intercropping											
	I_1	I_2	I_3	I_4	I_1	I_2	I_3	I_4	I_1	I_2	I_3	I_4
F_1	1835	2067	2017	1439	4156	4468	4228	2879	1835	3136	2638	1887
F_2	2502	2396	2340	2309	5293	5139	5071	4936	2503	4316	3754	3420
F_3	2882	2758	2729	2699	6347	6217	6147	6071	2882	5511	4978	4463
F_4	2889	2764	2738	2714	6394	6260	6205	6068	2890	5537	5015	4500
F_5	2642	2523	2482	2450	5591	5418	5357	5205	2643	4598	4086	3680
F_6	2621	2506	2463	1940	5523	5405	5336	4110	2622	4520	3981	3109
SEm ±	70				155				97			
CD (P ≤ 0.05)	198				437				274			

Effect of Nutrient Management

Yield : As regards to the performance of pearl millet in terms of grain and straw yield as well as equivalent yield under different nutrient management treatments, a significant response to nutrient application was noticed from no application of fertilizer to 100% RDF. It was interesting to noted that significantly higher grain and straw yield as well as equivalent yield of pearl millet was obtained under treatment F_4 (5 t/ha FYM + RDF through inorganic fertilizer based on STV), which remained statistically at par with treatment F_3 (5 t/ha FYM + 100% RDF through inorganic fertilizer) over other treatments. Whereas, harvest index of pearl millet was not influenced significantly by nutrient management treatments. The significant increase in yield of pearl millet with these treatment (F_4 & F_3) may be due to adequate supply of essential elements which facilitated better growth and development of pearl millet *via*., increase in plant height, dry matter accumulation and possibly a result of higher uptake of nutrients, efficient partitioning of photosynthates into reproductive parts and also due to significantly higher values of yield attributes ultimately resulted in higher yield of pearl millet. Similarly, Apoorva *et al*. (2010) and Kumar *et al*. (2014) observed that increasing nutrient supply to pearl millet will help to increased grain yield of pearl millet.

Quality : Protein content in grain of pearl millet as well as protein yield were recorded higher with application of 5 t/ha FYM + RDF through inorganic fertilizer on base of STV (F_4), which remained statistically at par with treatment F_3 (5 t/ha FYM + 100% RDF through inorganic fertilizer). The increase in protein content might be due to supply of nitrogen is related to the utilization of carbohydrate and formation of protein. Adequate supply of nitrogen developed conditions which are favourable for formation of proteins. Similar results have also been reported by Parihar *et al*. (2012) and Kumar *et al*. (2014)

Nitrogen content in grain and straw (%) : An examination of data indicated that nitrogen content in grain and straw of pearl millet was significantly influenced by nutrient management practices applied to pearl millet. Pearl millet crop fertilized with 5 t/ha FYM + RDF through inorganic fertilizer on base of STV (F_4) resulted in significantly higher values of nitrogen content in grain and straw which remained statistically at par with the treatment F_3 (5 t/ ha FYM + 100% RDF through inorganic fertilizer). It might be due to application of nitrogen through STV aids plant to fulfill its nitrogen needs during vegetative phase and because of mobile nature of nitrogen in plant it leads to translocation and accumulation in grains during reproductive stage. These results are in confirmation with the findings of Chejara *et al*. (2003) as well as Choudhary and Gautam (2008).

Phosphorus content in grain and straw (%) : Significantly higher phosphorus content in grain and straw was recorded with treatment F_4 (5 t/ha FYM + RDF through inorganic fertilizer on base of STV), which remained statistically at par with treatments F_3, F_6 and F_5 for grain and F_3 for straw. The results of phosphorus content in grain of pearl millet showed that application of FYM with inorganic fertilizer significantly improve phosphorus content in grain of pearl millet over the sole application of inorganic fertilizer. It might be due to application of inorganic fertilizer with FYM helps the plant to get phosphorus, whenever it demands. An adequate supply of phosphorus early in the life cycle of plant is important in laying down the primordia of its reproductive part. These results are on the line with the findings of Krishnaprabu (2019).

Potassium content in grain and straw (%) : Further, an examination of data indicated that all the treatments of nutrient management used in this experiment did not show any significant effect on potassium content in grain and straw of summer pearl millet. Crop fertilized

with 5 t/ha FYM + RDF through inorganic fertilizer on base of STV (F_4) resulted in higher values of potassium content in grain and straw followed by F_3 (5 t/ha FYM + 100% RDF through inorganic fertilizer). The findings are in close agreement with those obtained by Bharati and Thakare (2022).

Interaction Effect

The interaction effect of intercropping system and nutrient management showed significant difference in grain and straw yield of pearl millet. Treatment combination I_1F_4 (sole pearl millet alongwith 5 t/ha FYM + RDF through inorganic fertilizer on base of STV) resulted in significantly higher grain and straw yield but it remained statistically at par with treatment combinations I_1F_3, I_2F_4, I_2F_3, I_3F_4, I_3F_3, I_4F_4 and I_4F_3. While pearl millet equivalent yield was recorded significantly higher under treatment combination I_2F_4 (pearl millet + greengram intercropping system along with application of 5 t/ha FYM + RDF through inorganic fertilizer on base of STV) and it was found at par with I_2F_3 (pearl millet + greengram intercropping system along with application of 5 t/ha FYM + 100% RDF through inorganic fertilizer). The findings are in accordance with the work of Gaina *et al*. (2014) and Patel (2021).

Conclusion

From the result of two year study, it can be concluded that for obtaining proper growth, profitable yield and quality, pearl millet + greengram (2:1 row ratio) intercropping system alongwith application of 5 t/ha FYM + 100% RDF through inorganic fertilizer (80:40:00 NPK kg/ha) to pearl millet and 100% RDF to greengram (area based) should be followed during summer season under south Gujarat condition.

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“V. M. Patel and V. N. Shiyal designed the study”, V. N. Shiyal performed the research, statistical analysis, wrote the protocol and wrote the first draft of the manuscript, managed the analyses of the study and literature searches. The remaining author assisted in the research work. All authors have read and approved the final manuscript.

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