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Effect of integrated nutrient management on growth, yield and quality of summer green gram (*Vigna radiata* L.): *kharif* finger millet (*Eleusine coracana* L.) cropping sequence under South Gujarat condition

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Abstract
In the years 2019 and 2020, a field experiment was carried out at the College Farm of the Navsari Agricultural University. The soil in the test field had a clayey texture, was low in organic carbon (0.40%), low in available nitrogen (213.42 kg/ha), medium in available phosphorus (37.55 kg/ha), and high in accessible potassium (318.27 kg/ha). The soil had a reaction pH of 7.96, which was mildly alkaline. The treatment consisted of integrated nutrient management *viz.*, T_1 - Absolute control, T_2 - 100% RDF (20-40-00 NPK kg/ha), T_3 - 100% RDF + bio-compost @ 2.5 t/ha, T_4 - 100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 l/ha), T_5 - 50% RDF + bio-compost @ 2.5 t/ha, T_6 - 50% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 l/ha) to green gram in summer season as main plot treatment, replicated four times in randomized block design. Each main plot treatment during the *kharif* season was divided into three sub plot treatments with three levels of recommended fertilizer dosage, namely F_1 - 100% RDF + crop residue incorporation (40-20-00 NPK kg/ha), F_2 - 75% RDF + crop residue incorporation, and F_3 - 50% RDF + crop residue incorporation in finger millet. This resulted in eighteen treatment combinations that were replicated four times in split plot design. There was a higher yield in the treatment combination T_4F_1 because, in south Gujarat, the *kharif* finger millet crop should be fertilized with 100% RDF + crop residue incorporation (40-20-00 N-P_2O_5-K_2O kg/ha) and the summer green gram crop should be nourished with 100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 l/ha).

Keywords: Green gram, finger millet, cropping sequence, bio-compost, integrated nutrient management, growth, yield

Introduction

Considering that green gram ranks third among pulse crops, it is a significant pulse crop in India. Its productivity is 407 kg/ha, and it is grown on an area of 3.44 million hectares, producing 1.4 million tonnes in total (Anon., 2017a) [2]. With an annual production of 1.21 lakh tonnes and an average productivity of 526 kg/ha, Gujarat is home to around 2.3 lakh hectares of cultivation (Anon., 2017b) [3]. A significant pulse crop with great nutritional value is green gram (*Vigna radiata* L.). It contributes significantly to both human nutrition and soil fertility by fixing atmospheric nitrogen. It is a great crop for intercropping systems with other important crops because of its short duration. It is also raised as a crop for green manure. It prevents weed growth and reduces soil erosion because it is a crop that spreads quickly. Being a legume, it enriches the soil with nitrogen. Additionally, there is a chance to strengthen the system by adding green gram as a catch crop in the summer, which helps to improve the nutrient status of the soil (Venkatesh *et al.*, 2015) [14].

Mung, moong, mungo, golden gram, Chickasaw pea, and Oregon pea are further names for green gram. It has a 25.7% protein content, a 1.3% fat content, a 3.5% mineral content, a 4.1% fibre content, and a 56.7% carbohydrate content. Green gram has a two to three times higher protein content than grains. It is eaten in homes in a number of ways as a whole grain and dal; patients enjoy it since it is simple to digest. It is prized for its superior flavour, high level of digestion, and lack of the "flatulency effect" linked to other pulses. In addition to riboflavin and thiamine, ascorbic acid (Vitamin C) is also produced when moong beans are allowed to sprout. Finger millet is one of the most nutrient-dense crops for protein, minerals (calcium and iron), and delivers 8–10 times as much calcium as wheat or rice among the major dietary grains (Anon., 2014) [1].

Finger millet has the special ability to digest more slowly, making it an excellent food crop for diabetics and expectant mothers. According to Watt and Breyer-Brandwijk (1962) [15], finger millet has been used as a treatment for a number of ailments.

The third most significant millet in India after sorghum and pearl millet, finger millet [*Eleusine coracana* (L.) Gaertn.] is planted over an area of 1.13 million hectares with an annual production of 1.98 million tonnes and a productivity of 1661 kg/ha. It is grown on 44,000 hectares in Andhra Pradesh with a productivity of 1045 kg/ha and a production of 36,000 tonnes (Ministry of Agriculture and Cooperation, 2016) [10]. A significant tiny millet crop grown in India, finger millet takes pleasure in having the best yield of all millets. It is a significant staple food crop in parts of eastern and central Africa as well as India and is also referred to as ragi, African millet, and Bird's foot millet. In some hilly places, where it is produced for both grain and fodder purposes, it actually constitutes the majority of the cereal harvest during the monsoon season. Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Uttaranchal, Maharashtra, and Gujarat are among the Indian states where it is grown.

Legume-cereal rotation has been shown to improve soil fertility and boost crop output. To lower fertilizer costs, nutrient control in sequential cropping is crucial. While applying chemical fertilizer can increase crop yields, it degrades the physico-chemical characteristics of the soil. Therefore, to prevent nutrient depletion, preserve soil fertility, and increase crop yield, an integrated use of several sources of plant nutrients is necessary. The biological equilibrium in the soil is altered by rotations. A better idea for the modern day would be the inclusion of short-lived legume crops in the finger millet cropping system. Along with enhancing the physical and chemical qualities of the soil, these pre-*kharif* legumes supplement the nitrogen requirements of the subsequent crop. Green gram is a grain legume that is more advantageous since it provides farmers with immediate extra benefits and works just as well to maintain the productivity of the finger millet cropping system.

Materials and Methods

2019 and 2020 saw the execution of a field experiment at the College Farm of the Navsari Agricultural University. The soil in the test field had a clayey texture, low levels of organic carbon (0.40%), accessible nitrogen (213.42 kg/ha), medium levels of phosphorus (37.55 kg/ha), and a high level of potassium (318.27 kg/ha). As a reaction, the soil had a pH of 7.96, which was slightly alkaline. The treatment consisted of integrated nutrient management *viz*., T_1 - Absolute control, T_2 - 100% RDF (20-40-00 NPK kg/ha), T_3 - 100% RDF + bio-compost @ 2.5 t/ha, T_4 - 100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 l/ha), T_5 - 50% RDF + bio-compost @ 2.5 t/ha, T_6 - 50% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 l/ha) to green gram in summer season as main plot treatment, replicated four times in randomized block design. Each main plot treatment in the finger millet *kharif* season was divided into three sub plot treatments, each with three levels of recommended fertilizer doses: F_1 - 100% RDF + crop residue incorporation (40-20-00 NPK kg/ha), F_2 - 75% RDF + crop residue incorporation, and F_3 - 50% RDF + crop residue incorporation. This resulted in eighteen treatment combinations that were replicated four times in split plot design. Urea was used to apply nitrogen fertilizer while SSP was used as a base application for phosphorus. The appropriate amount of bio-compost was calculated according to the treatments, and bio fertilizer was completely combined with bio-compost. In certain plots, it was then evenly distributed and blended prior to seeding. Five randomly chosen plants from the net plot were subjected to biometric observations. The ring line and the net plot area were used to gather samples for the observations that needed destructive sampling. Utilizing statistical techniques as given by Panse and Sukhatme (1985) [11], the means of all observations were used for statistical analysis. The 'F' test was used to examine the treatment effects on each character in the study, and the data was analyzed using a split plot and randomized block design.

Results and Discussion

Effect on growth and yield parameters

Plant height, productive tillers per plant, ears per m^2, ear length, number of fingers per ear, and test weight of finger millet were measured under the residual effect of application of 100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 t/ha) - T_4, but they were comparable to treatment T_3 - 100% RDF + bio-compost @ 2.5 t/ha over the course of both years and in the pooled analysis. During both the years of the study and in the pooled analysis, treatment absolute control (T_1) had the lowest growth and yield attribute features of *kharif* finger millet. Higher growth and yield characteristics were seen in treatment T_4 as a result of the bio-compost that had been added to the previous crop's soil. The nutrients are available to the crops for a longer period of time since the rate of release of nutrients from organic sources is somewhat slower than that of inorganic ones. Additionally, the crop that came before was green gram, which also served as green manure. In addition to symbiotic nitrogen fixation, green manuring using legumes is known to recycle nutrients from the deeper soil layers. Therefore, the subsequent finger millet crop benefited from these INM treatments due to enhanced vegetative growth and the development of growth characteristics. Goudar *et al*. (2017) [5], Hebbal *et al*. (2018) [7], and Vamshi Krishna *et al*. (2019) [13] all came to similar conclusions.

Effect on yield parameters and yield

Higher grain yield of finger millet (2203, 2225 and 2214 kg/ha) and straw yield (4976, 5085 and 5030 kg/ha) were recorded by treatment T_4 - 100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 t/ha) during the year 2019, 2020 and in pooled, respectively and followed by treatment T_3 (100% RDF + bio-compost @ 2.5 t/ha). Treatment T_1 (Absolute control) resulted in significantly lowest grain and straw yield of *kharif* finger millet during both the years of study and pooled analysis, respectively. The response was in the order of T4>T3>T2>T6>T5>T1. Treatment combination T_4F_1 gave significantly highest grain yield of finger millet (2412, 2430 and 2421 kg/ha) during the 1st, 2nd year and pooled analysis, respectively. Treatment combination T_4F_1 was at par with treatment combination T_4F_2 during first year. While, significantly lower values of grain yield of finger millet (1403, 1498 and 1450 kg/ha) were observed in treatment combination T_1F_3 during both year as well as in pooled study, respectively. The better development of yield attributes may be an outcome of enhanced availability of nutrients to the finger millet crop from its own nutrient pool as well as the residual effect of the INM treatments in preceding crop. More absorption of nutrients led to more assimilation in the fruiting parts which ultimately enhance the development of yield contributing characters and also grain yield and straw yield. These findings are close conformity with Sandhya *et al.* (2017) [12], Hatti *et al.* (2018) [6] and Manojgowda *et al.* (2020) [9].

Effect on quality parameter

Crude protein content and crude protein yield of finger millet significantly higher recorded in treatment T_4 (100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 t/ha) which was followed by treatment T_3 (100% RDF + bio-compost @ 2.5 t/ha) during both the years of study and in pooled data. Treatment T_1 (control) resulted in significantly lowest nutrient content, uptake, crude protein content and crude protein yield of finger millet during both of the years and in pooled analysis. Combined effects of organic manure and inorganic fertilizer that facilitated continuous supply of nutrients resulting into improved protein content in the grain. These findings were in accordance with Hossain *et al.* (2009) [8] and Dixit *et al.* (2015) [4].

Table 1: Plant height, Number of productive tillers per plant, dry matter accumulation, EAR length, number of fingers per ear and test weight of *kharif* finger millet as influenced by different treatments

Treatments	Plant Height			Number of productive tillers per plant	Dry matter accumulation (g/plant) at harvest	Ear length (cm)	Number of fingers per ear	Test weight
	30 DAT	60 DAT	At Harvest					
Main plot (applied to green gram)								
T_1: Absolute control	24.72	55.24	94.83	2.13	21.23	5.86	5.91	2.65
T_2: 100% RDF	27.49	65.49	103.81	3.15	24.78	7.47	6.76	2.86
T_3: 100% RDF + Bio-compost @ 2.5 t/ha	28.58	68.08	105.95	3.48	25.31	7.56	6.88	2.90
T_4: 100% RDF + Bio-compost @ 2.5 t/ha + PSB (soil application 2.5 l/ha)	30.22	69.51	109.13	3.99	25.86	7.84	7.07	3.09
T_5: 50% RDF + Bio-compost @ 2.5 t/ha	26.58	62.45	95.38	2.73	21.87	6.82	6.54	2.74
T_6: 50% RDF + Bio-compost @ 2.5 t/ha+ PSB (soil application 2.5 l/ha)	27.31	65.47	101.72	2.86	23.15	7.25	6.77	2.86
S.Em ±	0.60	1.47	1.57	0.07	0.48	0.11	0.11	0.07
CD (P=0.05)	1.73	4.24	4.53	0.22	1.38	0.32	0.33	NS
CV (%)	10.66	11.12	7.54	11.58	9.93	7.71	8.29	11.8
Sub-plot (applied to finger millet)								
F_1: 100% RDF + crop residue incorporation	28.45	66.23	104.45	3.32	24.99	7.38	6.88	2.98
F_2: 75% RDF + crop residue incorporation	27.31	64.46	101.56	2.96	23.50	7.15	6.72	2.89
F_3: 50% RDF + crop residue incorporation	26.78	63.44	99.89	2.88	22.60	6.87	6.45	2.76
S.Em ±	0.37	0.67	0.89	0.04	0.12	0.06	0.06	NS
CD (P=0.05)	1.08	2.03	2.52	0.11	0.34	0.18	0.18	0.09
Interaction (T × F)								
S.Em ±	0.90	1.89	2.20	0.09	0.29	0.15	0.16	0.08
CD (P=0.05)	NS	NS	NS	0.26	NS	NS	NS	NS
Sig. interactions with Y	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	9.31	7.21	6.09	9.79	6.87	6.08	6.87	7.73

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Crude protein content (%)	Crude protein yield (kg/ha)
Main plot (applied to green gram)				
T1: Absolute control	1533	3869	4.58	70.32
T2: 100% RDF	1877	4878	5.53	103.85
T3: 100% RDF + Bio-compost @ 2.5 t/ha	1986	4965	5.73	114.08
T4: 100% RDF + Bio-compost @ 2.5 t/ha + PSB (soil application 2.5 l/ha)	2214	5030	6.15	136.42
T5: 50% RDF + Bio-compost @ 2.5 t/ha	1775	4293	5.05	89.55
T6: 50% RDF + Bio-compost @ 2.5 t/ha+ PSB (soil application 2.5 l/ha)	1854	4515	5.22	96.75
S.Em ±	42.39	119.31	0.10	2.85
CD (P=0.05)	122	345	0.29	8.26
CV (%)	11.08	13.30	9.31	13.80
Sub-plot (applied to finger millet)				
F1: 100% RDF + crop residue incorporation	1989	4773	5.56	111.41
F2: 75% RDF + crop residue incorporation	1887	4582	5.34	101.84
F3: 50% RDF + crop residue incorporation	1744	4351	5.19	91.26
S.Em ±	12.47	43.78	0.06	1.19
CD (P=0.05)	35	123	0.17	3.35
Interaction (T × F)				
S.Em ±	30.56	107.26	0.15	2.92
CD (P=0.05)	86	301	NS	NS
Sig. interactions with Y	NS	NS	NS	NS
CV (%)	6.82	6.57	7.93	8.14

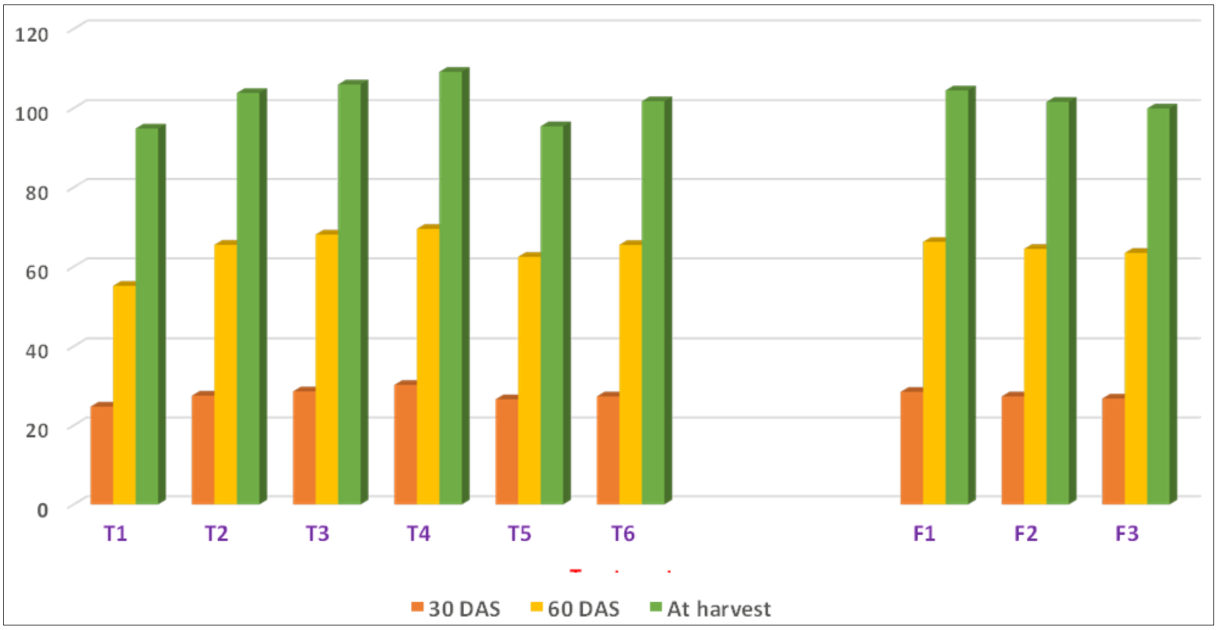

Fig 1: Plant height of *kharif* finger millet as influenced by different treatments

Conclusion

On the basis of experimental results, it can be concluded that for getting higher yield and quality, summer green gram crop should be nourished with 100% RDF + bio-compost @ 2.5 t/ha + PSB (soil application @ 2.5 l/ha) (RDF: 20-40-00 N-P_2O_5-K_2O kg/ha) and *kharif* finger millet crop should be fertilized with 100% RDF + crop residue incorporation (40-20-00 N-P_2O_5-K_2O kg/ha) in green gram – finger millet sequence under south Gujarat condition.

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