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RESEARCH ARTICLE

Influence of planting pattern and nutrient management on plant growth, yield and quality of sweet corn in a rainfed sweet corn-cowpea intercropping system

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Abstract

Intercropping, a sustainable agricultural practice, enhances land use efficiency, soil fertility and overall crop productivity. This study uses a split-plot design to evaluate the effects of various Sweet corn (SC) + Cowpea (CP) intercropping patterns and nutrient management strategies on sweet corn growth, yield and quality during 2019 and 2020 cropping years. The hypothesis was that intercropping, combined with optimal nutrient management, can significantly enhance the performance of sweet corn. Amongst the planting pattern and nutrient management practices, sweet corn and cowpea planted in alternate paired rows of 2:2 and 75 % of the soil test based recommended fertilizer (STBFR) to SC and STBFR to CP, supplemented with consortia biofertilizer (BC) gave superior results in terms of growth, yield and yield attributing characters as compared to other treatments. Specifically, SC planting with CP in 1:1 and 2:2 ratios showed a yield increase of 13 % to 15.6 % over the same-row planting. Although the planting pattern did not significantly influence the quality parameters of SC, the nutrient management practice involving 75 % STBFR with BC resulted in the highest accumulation of total sugars (10.8 %), reducing sugars (1.98 %), non-reducing sugars (8.55 %) protein content (8.69 %), total soluble solids (TSS) value (15.79 °Brix), phenol content (0.19 %) and calcium content (42.73 mg) in the kernels. The study suggested that intercropping sweet corn and cowpea in a 2:2 row pattern, combined with 75 % STBFR to SC + STBFR to CP + BC, is a sustainable and economically beneficial practice for farmers.

Keywords: cowpea planting pattern; protein content; STBFR; sweet corn; yield

Introduction

The nutritional profile of sweet corn, a type of corn, is widely recognized because of its sugar content, dietary fiber, potassium, vitamin C, niacin and beta-carotene. Its appealing sweetness further contributes to its growing popularity (1). The potassium content of sweet corn is remarkable (2). Sweet corn has numerous health benefits largely ascribed to the higher availability of phenols, the bioactive phytochemicals. Phenols are antioxidants with radical scavenging and anti-inflammatory properties and protect from cancer and neurological disorders in human beings (3). Among the vegetables, after potatoes and tomatoes, sweet corn is ranked third among the highest suppliers of total phenols (4). The quality of the sweet corn kernel is determined by its sugar and water content (5). The accumulation of sugars specifies flavour in the sweet corn kernels and is considered the most essential component that consumers consider while buying (6). Therefore, it is a popular vegetable as it has high sugar and low starch content (7). For sweet corn cobs' processing, the kernel's moisture content is the primary quality standard.

Sweet corn ranks fourth among the commercial crops, whereas its position is second with regards to farm value. As the demand for sweet corn continues to increase, it is essential to ensure proper spatial arrangement of the plants in the field to achieve higher productivity. This arrangement regulates the size and shape of each plant ideotype, affecting the efficient interception of the sun's rays, root growth and overall plant activity (8). Another factor that is responsible for optimum yield is nutrient management. Sweet corn is an exhaustive crop, so the farmers are indiscriminately using chemical fertilizers, which will become a major constraint on increasing agricultural production in the future (9). Therefore, a nutrient management system that combines the strategic use of biofertilizers, compost and chemical fertilizers is essential to ensure sustained long-term crop productivity improvements. Biofertilizers have been considered superior to chemical fertilizers, as they furnish the crops with nutrients along with the substances that can boost the growth of the plants like various amino acids, vitamins, hormones, etc. thereby enhancing the quality of produce (10). Therefore, this study aims to maximize yield along with magnification of the quality of the product by utilizing proper planting patterns and management of nutrients.

Methodology

A research trial was conducted in the *kharif* season of the year 2020 and 2021 at the RRTTS, OUAT, Keonjhar farm, Odisha to discover the effect of planting dynamics and nutrient management strategy on quantitative and qualitative analysis in rainfed sweet corn + cowpea intercropping system. In the 2019-20 and 2020-21 growing seasons. The average precipitation was 1007 mm and 935 mm with 51 and 44 wet days in each season. The temperature was maximum in June in both the years (34.1 °C and 32.4 °C) and minimum in August (30.3 °C and 30.2 °C). The monthly relative humidity varied from 70 % to 90 % during crop growing system. The experiment was carried out in split plot statistical design as planting pattern of sweet corn and cow pea in main plot while nutrient management in subplot with three replications. A total of three levels of planting patterns and seven levels of nutrient management practices were used in this experiment. The planting patterns are as follows: P_1: sweet corn (SC) + cowpea (CP) planted in the alternate rows (1:1), P_2: SC + CP planted in alternate paired rows (2:2) and P_3: SC + CP planted in the same row (1:1). In nutrient management, F_1: soil test based fertilizer recommendation (STBFR) to SC; F_2: the proportion of STBFR to (SC + CP) based on population density; F_3: STBFR to SC + biofertilizer consortium (BC); F_4: population density-based 75 % STBFR to SC + STBFR to CP; F_5: 50 % STBFR to SC + STBFR to CP; F_6: 75 % STBFR to SC + STBFR to CP + BC; F_7: 50 % STBFR to SC + STBFR to CP + BC. The test crop used was Syngenta's Sugar 75 variety of sweet corn. It is suitable for all the three seasons *viz.*, *kharif, rabi* and summer and has very good plant vigour, attains height of about 5-6 feet and matures in 78-85 days with yield potential of 8 tons per acre. STBFR to sweet corn was applied @ 120: 60: 60 kg N: P_2O_5: K_2O ha^{-1} and STBFR to cowpea was applied @ 25: 50: 50 kg N: P_2O_5: K_2O ha^{-1}. The consortia biofertilizer (Azotobacter, Azospirillium and Phosphorus solubilizing bacteria in the ratio 1:1:1) was applied @ 12 kg ha^{-1}. The texture of the soil of the investigating site was sandy loam and had a pH of 6.4, OC of 6.93 g kg^{-1}, nitrogen of 288.2 kg ha^{-1}, phosphorus of 18.4 kg ha^{-1} and potassium of 119.2 kg ha^{-1}. The cultural operation, like irrigation, weeding and pest and disease management was done based on standard protocol. The following observations were recorded before the harvest of the crop

Plant height: The heights of the plants were measured in centimetres from the ground level up to the auricle of the fully expanded topmost leaf of sweet corn.

LAI: It was calculated by dividing the leaf area per plant by the land area occupied by single plant.

Crop growth rate :
$$\frac{W_2 - W_1}{t_2 - t_1} \quad \text{(Eqn. 1)}$$

Where, W_1 and W_2 was the dry weight of the aerial plants per unit area gained at time t_1 and t_2 respectively.

Yield attributing characters like cob length, cob weight, cobs/ plant, no of seed rows per cob, the girth of the sweet corn, fresh (green) cob yield and fresh (green) fodder yield were recorded after the harvest of the crop.

The observations of quality parameters like starch, total, reducing and non-reducing sugars by Anthrone method, protein content (%) by Lowry method, calcium content by Versenate method, total soluble solids by Hand refractometer and phenols by Folin–Ciocalteau reagent were recorded by adopting the standard protocol (11-15). For moisture content, the sweet corn kernels were removed, the fresh weight was recorded and then kept in aluminium boxes and oven-dried at 80 °C. After this, the oven-dried samples were weighed and then the percentage of moisture content was calculated by using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{(Fresh weight - Dry Weight)}}{\text{Fresh Weight}} \times 100 \quad \text{(Eqn. 2)}$$

Statistical analysis

All the data recorded were measured in triplicate (n=3) and the results were presented as the pooled of two years of experimentation. One-way analysis of variance (ANOVA) was applied to the data and whether the data were significantly different or at par was assessed using Fisher's protected least significant difference (LSD) at a significance level of $P < 0.05$.

Results and Discussion

Plant growth attributes

Planting pattern and nutrient management practice significantly affected the plant growth indicators of sweet corn. During the harvest maximum height of the plants was recorded with the planting pattern SC + CP (2:2) planted alternately in paired rows (183.6 cm) being at par with SC + CP (1:1) planted in alternate rows (Table 1). This results aligns with previous findings which reported that LAI enhances productivity by increasing total light interception (16). Among the nutrient management practices the minimum plant height was reported with the application of STBFR to SC (164.6 cm). Various nutrient management techniques showed a statistically significant increase in plant height. Application of 75 % STBFR to sweet corn + STBFR to cowpea + consortia biofertilizer recorded the tallest plants of 186.4 cm and was

Table 1. Effect of planting pattern and nutrient management on growth and yield attributes of sweet corn at harvest

Treatments	Plant height (cm)	LAI	Dry matter (g m^{-2})	Cobs plant^{-1}	Cob length (cm)	Cob girth (cm)	No of seed rows cob^{-1}	Cob weight (g)
Planting pattern								
SC + CP (1:1)	173.1	4.14	1019.2	1.2	20.4	11.4	15.0	300.9
SC + CP (2:2)	183.6	4.18	1043.3	1.3	21.7	12.3	15.4	313.6
SC + CP (1:1 in same row)	164.4	3.73	924.3	1.0	19.3	10.8	14.6	277.4
S.Em. (±)	1.99	0.01	25.76	0.01	0.43	0.8	0.7	4.47
CD(P=0.05)	6.9	0.036	89.4	NS	1.5	NS	NS	15.5
Nutrient management								
STBFR to SC	164.6	3.55	908.4	1.0	19.0	10.6	14.4	259.5
STBFR to SC + CP	181.1	4.23	1034.1	1.2	21.1	12.9	15.4	317.6
STBFR to SC + BC	171.9	4.12	987.8	1.1	20.8	12	14.8	296.9
75 % STBFR to SC + STBFR to CP	169.2	4.01	968.9	1.1	20.3	11.4	14.6	286.9
50 % STBFR to SC + STBFR to CP	164.6	3.87	939.2	1.0	19.7	11.1	14.6	279.9
75 % STBFR to SC + STBFR to CP + BC	186.4	4.26	1064.2	1.3	21.7	13.3	15.6	340.8
50 % STBFR to SC + STBFR to CP + BC	178.1	4.08	1012.8	1.1	20.7	10.6	15.0	299.5
S.Em. (±)	2.68	0.01	27.32	0.02	0.26	1.5	1.4	3.69
CD(P=0.05)	9.3	0.03	94.8	NS	0.9	NS	NS	12.8

#SC: Sweet corn, CP: Cow pea, STBFR: soil test based fertilizer dose; BC: biofertilizer Consortia, LAI: Leaf area index

higher than the rest of the nutrient management practices (Table 1). Nitrogen is an essential component of the plant tissue responsible for the rapid division of cell and its expansion. Phosphorus and potassium enhance the division of cell and cell enlargement. In addition to the chemical fertilizers, the beneficial effect of biofertilizers also contributes to the available nutrients. Applying NPK fertilizer in conjunction with biofertilizers significantly raised the height of the sweet corn plant because these substances promote growth by boosting the accessibility to nitrogen and by producing auxin, cytokinin and gibberellins, all of which are beneficial to plant growth (17). Additionally, these substances have a major impact in the transportation and accessibility of minerals in fixed forms. At harvest, SC + CP (2:2) in alternate paired rows recorded the maximum LAI (5.21), which was at par with SC + CP (1:1) in alternate rows (Table 1). Lower values of LAI were recorded with SC + CP (1:1) in alternate rows. Among the nutrients management practices, maximum LAI was recorded with 75 % STBFR to SC + STBFR to CP + BC (5.5) which was at par STBFR to (SC + CP) and 50 % STBFR to SC + STBFR to CP + BC. Bio fertilizer application not only improves the soil's biological and physico-chemical properties but also helps release sufficient nutrients from the soil to enhance the crop growth by increasing the leaf area index. The other treatments differed significantly during both years and the pooled data. The lowest LAI was recorded with STBFR to sweet corn (Table 1). The dry matter production of sweet corn was maximum at the harvest of the crop in all the treatments. SC + CP (2:2) in alternate paired rows (P_2) documented sweet corn's maximum dry matter production at harvest. This treatment was at par with SC + CP (1:1) in alternate rows (P1). Planting pattern SC + CP (1:1) in the same row (P_3) was statistically inferior to these treatments. The increased production of dry matter may be attributed to the better accessibility to the natural resources, including interception of an adequate amount of solar radiation, proper aeration and optimal humidity, accompanied by the positive effects of leguminious crop inclusion in paired row planting. Nutrient management practices at successive growth stages significantly affected dry matter production. Considering pooled data, the application of STBFR to SC (F_1) registered the minimum dry matter production (908.4 g m^{-2}) of sweet corn at harvest. Application of 75 % STBFR to SC + STBFR to CP + BF recorded the maximum dry matter production at all the successive growth stages and at harvest (1064.2 g m^{-2}) which was statistically similar to F_2 (STBFR to (SC + CP)) and F7 (50 % STBFR to SC + STBFR to CP + BC). The rest of the treatments were inferior to these three treatments. The periodic increase in the plant height and the leaf area index lead to the optimum interception of light by the crop which assembles more photosynthate, thereby producing more dry matter by utilizing both organic and inorganic fertilizers in combination. The crop growth rate (CGR) of sweet corn has been observed and documented from 15 DAS till harvest (Fig. 1). When different planting pattern is taken into consideration, maximum crop growth rate was recorded with sweet corn + cowpea (2:2) in alternate paired rows i.e. 3.68, 3.62 and 3.68 g/m^2/day at 30-45 and 8.52, 8.69 and 8.60 g/m^2/day at 45 DAS-harvest during the year 2019-20, 2020-21 and pooled data respectively. This treatment was statistically superior to the rest of the two planting patterns. Among the various nutrient management practices, 75 % STBFR to sweet corn + STBFR to cowpea + consortia bio fertilizer recorded the maximum CGR values of 3.76, 3.67 and 3.61 g/m^2/day at 30-45 and 8.68, 8.99 and 9.00 g/m^2/day at 45 DAS-harvest, during the first year and second year of experimentation and pooled data respectively. The rest of the treatments were statistically inferior to these treatments. At 45-60 DAS and 60-75 DAS F6 was statistically superior to the rest of the treatments. During all cropping experimentation years, the minimum CGR value was recorded with STBFR to SC (F_1) at all the growth stages.

Yield attributing characters

The number of cobs per plant, the girth of the sweet corn cobs and the seed rows per cob were not significantly

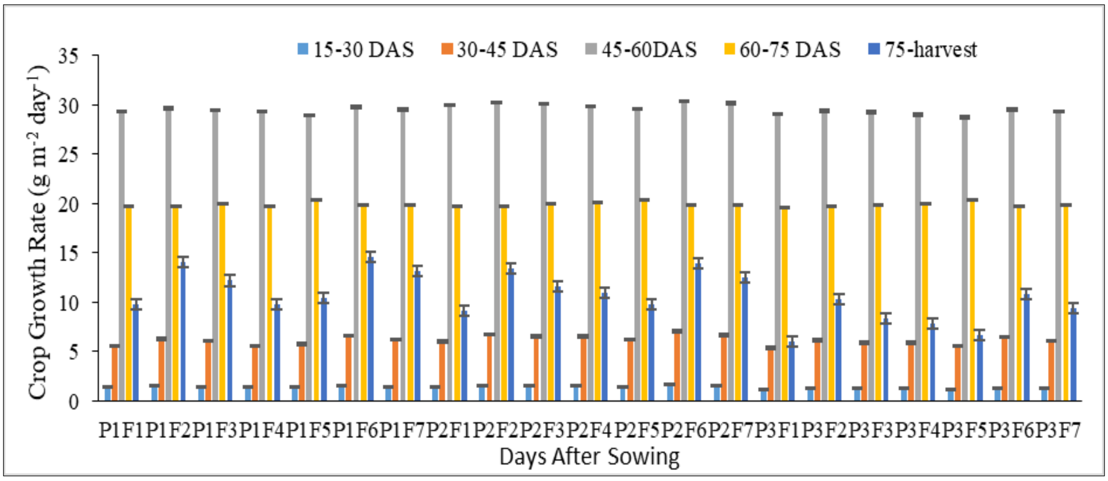

Fig. 1. Effect of planting pattern and nutrient management on crop growth rate (g m^{-2} day^{-1}) of sweet corn. Where, SC: Sweet corn, CP: Cow pea, STBFR: soil test based fertilizer dose; BC: biofertilizer Consortia, P_1- SC + CP (1:1), P_2- SC + CP (2:2), P_3-SC + CP (1:1 in same row), F_1-STBFR to SC, F_2- STBFR to SC + CP, F_3- STBFR to SC + BC, F_4- 75 % STBFR to SC + STBFR to CP, F_5- 50 % STBFR to SC + STBFR to CP, F_6-75 % STBFR to SC + STBFR to CP + BC, F_7-50 % STBFR to SC + STBFR to CP + BC.

influenced by the planting pattern or nutrient management techniques in both the individual trial years and the pooled data (Table 1). The planting pattern significantly influenced the sweet corn cobs' length and weight. The longest and heaviest cobs were recorded with SC + CP (2:2) planted in alternate paired rows (21.7 cm, 313.6 g) which was at par with SC + CP (1:1) in alternate rows. SC + CP (1:1) in the same rows produced significantly smaller and lighter cobs than the rest of the two planting patterns. Among the nutrient management practices, application of 75 % STBFR to SC + STBFR of CP + BC recorded the longest cob (21.7 cm) and cobs with maximum weight (340.8 g). The cob length of sweet corn was at par with STBFR to (SC + CP) (F_2) and 75 % STBFR to SC + STBFR of CP + BC (F_7). The cob weight in treatment $F_6$was statistically superior to the rest of the treatments (Table 1).

Yield of sweet corn and Sweet corn equivalent yield

Taking into account the various planting patterns, SC + CP (2:2) in alternate paired rows gave the maximum green cob and green fodder yield of 17.94 t ha^{-1} and 33.01 t ha^{-1}, respectively, which was at par with SC + CP (1:1) in alternate rows (Table 2). This might possibly be due to higher cell division and more translocation of photosynthates from source to sink. Previous studies reported that in maize + cowpea intercropping, the highest number of cob $plant^{-1}$ were recorded under 2:2 row ratio which is followed by 2:4 row ratio combination (18). Similarly, paired row planted maize + cowpea recorded 18.6 % more yield over 1:1 row ratio (19). Minimum green cob yield was recorded with SC + CP (1:1) in the same row and was statistically inferior to the rest of the treatments. Comparison of the pooled effect over the years of the nutrient management practices, the application of 75 % STBFR to SC + STBFR to CP + BC produced the maximum green cob yield as well as green fodder yield of 18.66 t ha^{-1} and 33.08 t ha^{-1}(Table 2). Supplementation of biofertilizer increased green cob yield in 75 % STBFR to SC + STBFR to CP + BC (F_6), STBFR to SC + BC (F_3) and 50 % STBFR to SC + STBFR to CP + BC (F_7) by 3.05 t ha^{-1} and 3.35 t ha^{-1} (19.5 % and 11.3 %), 1.22 t ha^{-1} and 2.08 t ha^{-1} (7.8 % and 6.9 %) and 2.15 t ha^{-1} and 2.3 t ha^{-1} (12.8 % and 7.7 %) respectively in comparison to STBFR to SC (F_1). The planting pattern and fertilizer used together sped up crop growth and development by increasing the production of metabolites, increasing the activity of photosynthetic pathways and improving the uptake of nutrients for the development of reproductive structures. This probably led to higher plant productivity. It has also been noted that the population of

Table 2. Effect of planting pattern and nutrient management on yield and harvest index of sweet corn at harvest (Pooled)

Treatments	Green cob yield (t ha^{-1})	Green fodder yield (t ha^{-1})	Harvest index (%)	Fresh cow pre pod yield (t ha^{-1})	Sweet corn equivalent yield of cowpea (t ha^{-1})
Planting pattern					
SC + CP (1:1)	17.53	31.81	35.10	1.83	1.01
SC + CP (2:2)	17.94	33.01	35.57	1.92	1.06
SC + CP (1:1 in same row)	15.51	29.93	34.17	1.52	0.84
S.Em. (±)	0.28	0.35	0.63	0.11	0.05
CD(P=0.05)	0.97	1.21	NS	0.32	0.14
Nutrient management					
STBFR to SC	15.61	29.73	34.44	1.54	0.85
STBFR to SC + CP	17.79	32.82	35.14	1.86	1.03
STBFR to SC + BC	16.83	31.81	34.59	1.77	0.97
75 % STBFR to SC + STBFR to CP	16.39	31.09	34.50	1.71	0.95
50 % STBFR to SC + STBFR to CP	15.90	30.51	34.26	1.66	0.91
75 % STBFR to SC + STBFR to CP + BC	18.66	33.08	36.05	1.95	1.07
50 % STBFR to SC + STBFR to CP + BC	17.76	32.03	35.64	1.82	1.00
S.Em. (±)	0.32	0.24	0.69	0.07	0.02
CD(P=0.05)	1.11	0.83	NS	0.21	0.06

#SC: Sweet corn, CP: Cow pea, STBFR: soil test-based fertilizer dose; BC: biofertilizer consortium microorganisms that are beneficial may increase in the soil due to application of an organic source of fertilizer to the sweet corn crop which increases the organic pool of the soil. This results in the increase in the availability of nutrients due to the production of the substances that promote growth throughout the crop growth period. Its beneficial effect can be seen during the crop harvest with higher yields (20). Application of STBFR to sweet corn reported the minimum green cob yield in both the years of experimentation and pooled analysis. Interaction effects of planting patterns and nutrient management practices on green cob and fodder yield were found significant (Fig. 2). Among planting patterns, SC + CP (2:2) in alternate paired rows with 75 % STBFR to SC + STBFR to CP + BC recorded maximum green cob and fodder yield of 18.45 t ha^{-1} and 33 t ha^{-1} respectively. The rest of the treatment combinations remained significantly lower than this treatment. The minimum green cob yield was recorded with a combination of SC + CP (1:1) in the same row and STBFR to sweet corn (15.75 t ha^{-1} and 29.27 t ha^{-1}, respectively). Neither the planting as well as nutrient management practices could not statistically influence the harvest index (%) of sweet corn (Table 2). It was found that among the planting pattern sweet corn + cowpea (2:2) in alternate paired row (P_2) produced the maximum fresh pod yield of cowpea (1.92 t ha^{-1}). There was a decline in the cowpea yield by 0.09 t (4.7 %) with sweet corn + cowpea (2:2) in alternate paired row (P_2) when compared with the planting pattern P_1. This reason might be that this planting pattern facilitated proper execution of cultural operations, permitted penetration of light to lower canopy of cowpea and helped in proper utilization of added nutrients. Another reason for higher intercrop yield of cowpea may be that cowpea can tolerate shade produced from sweetcorn and it fixes atmospheric nitrogen in the soil. Nutrient competition between sweet corn and vegetable cowpea is less so yield is increased in both crops. Treatment F_6 recorded the maximum fresh pod yield of 1.95 t ha^{-1} being at par with the rest of the treatments except for F_1, which proved statistically inferior to the rest. Similarly sweet corn equivalent yield (SEY) of cowpea was the maximum with planting pattern P_2 (1.06 t ha^{-1}) which was statistically at par with P_1. Among the various nutrient management practices, treatment F_6 recorded the maximum SEY of cowpea (1.07 t ha^{-1}) due to greater yields of the component crops, better soil condition, build-up of organic carbon and incorporation of organic fertilizers.

Quality parameters

The quality parameters of sweet corn was statistically similar with regards to the planting pattern but varied with the application of biofertilizers as well as varying levels of fertilizer application to the crops. The application of 75 % STBFR to SC + STBFR to CP + BC (F_6) was observed to be the best in terms of maximum accumulation of total sugars, reducing sugars and non-reducing sugars in the sweet corn kernels which were comparable with STBFR to (SC + CP) (F_2) and followed by 75 % STBFR to SC + STBFR of CP + BC (F_7) (Table 3). Phosphorus is an important nutrient that enhances the sugar content of sweet corn kernels. Phosphorus activates enzymes that convert fructose-6-phosphate and glucose-6-phosphate to sucrose-6-phosphate (21). When biofertilizers are applied to the soil, it increases the availability of phosphorus to the plants by releasing phosphorous from aluminium and iron oxides, also organic acids are released, mainly citric acid and maleic on the decomposition of organic manures by the microbes and consequently help in the solubilization of unavailable P (22). Application of 75 % STBFR to SC + STBFR to CP + BC manifested its supremacy in enhancing the quality of the kernels (Table 3). Higher protein content may be because this treatment made the kernels absorb more nitrogen, which raised their protein and amino acid content (23, 24). The soil nutrient availability enhanced due to the interaction between chemical fertilizers and biofertilizers. In addition to increasing the soil's overall N, P and K concentrations, these fertilizers also made these components more readily available, enabling sweet corn roots to uptake nutrients (25). The real-time addition of FYM and biofertilizers as well as increased soil microbial growth, which may transform organically bound N into inorganic form, maybe the cause of the increase in available N. Maximum starch content was recorded with F_1 (STBFR to SC (5.8 %) which was at

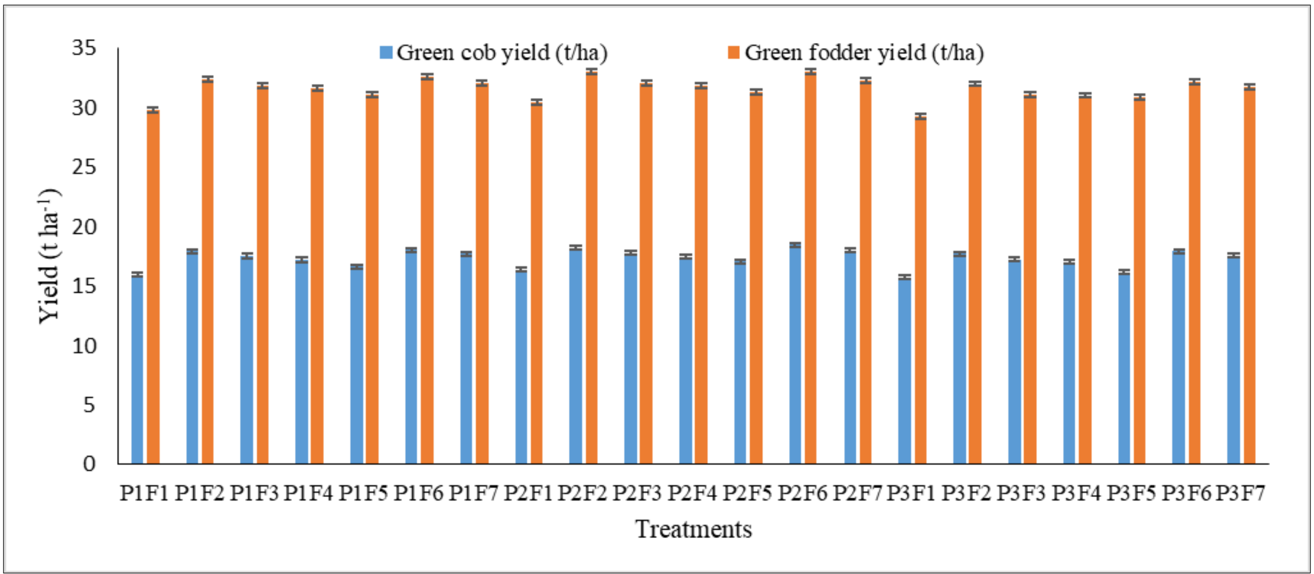

Fig. 2. Interaction effect of planting pattern and nutrient management on green fodder yield of sweet corn. Where, SC: Sweet corn, CP: Cow pea, STBFR: soil test based fertilizer dose; BC: biofertilizer Consortia, P_1- SC + CP (1:1), P_2- SC + CP (2:2), P_3-SC + CP (1:1 in same row), F_1- STBFR to SC, F_2- STBFR to SC + CP, F_3- STBFR to SC + BC, F_4- 75 % STBFR to SC + STBFR to CP, F_5- 50 % STBFR to SC + STBFR to CP, F_6-75 % STBFR to SC + STBFR to CP + BC, F_7-50 % STBFR to SC + STBFR to CP + BC.

Table 3. Effect planting pattern and nutrient management treatments on quality parameters of sweet corn

Treatments	RS (%)	NRS (%)	TSC (%)	PC (%)	SC (%)	MC (%)	TSS (⁰B)	Phenol(%)	Ca (mg $100g^{-1}$)
Planting pattern									
SC + CP (1:1)	1.81	8.78	10.97	8.62	5.4	78.1	15.57	0.17	40.62
SC + CP (2:2)	1.83	8.83	11.02	8.69	5.5	77.6	15.65	0.18	41.66
SC + CP (1:1 in same row)	1.79	8.75	10.90	8.61	5.4	78.4	15.54	0.16	38.67
S.Em. (±)	0.023	0.026	0.031	0.014	0.01	0.23	0.12	0.01	0.54
CD(P=0.05)	0.067	0.074	0.089	0.045	0.02	NS	0.25	0.02	1.21
Nutrient management									
STBFR to SC	1.10	8.27	10.02	8.31	5.8	78.6	14.94	0.13	37.16
STBFR to SC + CP	1.95	8.44	10.96	8.55	5.3	78.1	15.68	0.17	40.93
STBFR to SC + BC	1.77	8.33	10.54	8.44	5.2	78.0	15.71	0.17	41.03
75 % STBFR to SC + STBFR to CP	1.64	8.35	10.43	8.38	5.6	78.6	15.35	0.16	39.66
50 % STBFR to SC + STBFR to CP	1.55	8.39	10.38	8.38	5.7	78.3	15.22	0.15	38.64
75 % STBFR to SC + STBFR to CP + BC	1.98	8.55	10.98	8.69	5.1	77.9	15.79	0.19	42.73
50 % STBFR to SC + STBFR to CP + BC	1.80	8.40	10.69	8.50	5.2	78.3	15.77	0.17	41.08
S.Em. (±)	0.018	0.045	0.011	0.031	0.04	0.27	0.04	0.01	0.61
CD(P=0.05)	0.058	0.140	0.035	0.097	0.11	NS	0.10	0.04	1.88

#SC: Sweet corn, CP: Cow pea, STBFR: soil test based fertilizer dose; BC: biofertilizer Consortia, Reducing Sugar (%); NRS: Non-reducing sugar (%); TSC: Total Sugar Content (%); PC: Protein content (%); SC: Starch content (%); MC: Moisture content (%); TSS: Total soluble solid (⁰B)

par with F_5(50 % STBFR to SC) + STBFR(Cowpea) (5.7 %). The treatments that received biofertilizer i.e. treatment F_6(75 % STBFR to SC + STBFR to CP + BC), F_3 (STBFR to SC + BC) and F_7 (50 % STBFR to SC + STBFR to CP + BC) recorded less starch content (Table 3). Sweet corn has been regarded as an important vegetable because of its high sugar content and low starch level (7). The moisture content of the sweet corn kernels varied between 77.9 and 78.6; however, neither the planting pattern nor the nutrient management techniques had a significant impact. Treatment F_6 (75 % STBFR to SC + STBFR to CP + BC) recorded the maximum TSS value of "15.79 °B" or "15.79 °Brix" which was at par with 75 % STBFR to SC + STBFR of CP + BC (F_7) and STBFR to (SC + CP) (F_2) and superior to the rest of the varieties (Table 3). Similar results were reported by Agyenim et al. and Kumar (26, 27). Maximum Phenol content in the kernel was recorded with F_6 (75 % STBFR to SC + STBFR to CP + BC) (0.19 %) (Table 3). The addition of organic manures and biofertilizers may account for this, as they not only supply potassium (K) to the soil but also improve its availability by reducing K-fixation and promoting its release through interactions with clay. Similar positive effects of organic sources and the integration of different nutrients on increasing K content and phenol levels in sweet maize have been observed by previous studies (22, 28). Higher calcium content in sweet corn kernels was recorded with treatment F_6 (75 % STBFR to SC + STBFR to CP + BC) (42.73 mg) which was at par with F_3 (STBFR to SC + BC) and F_7(50 % STBFR to SC + STBFR to CP + BC) (Table 3). The content of calcium was lowest in sweet corn kernels in the treatment F_1 (STBFR to SC) which might be due to the better accessibility of K in the biofertilizer-applied treatments (29).

Conclusion

This comprehensive study on the effects of planting pattern dynamics and nutrient combinations on sweet corn and cowpea cropping systems has provided critical insights into sustainable agricultural practices. Based on the current findings, it can be suggested that including legume crops like cowpea can boost sweet corn yield, improve soil health and potentially reduce the need for chemical fertilizers. The results indicate that inter-cropping systems, coupled with strategic nutrient management, can substantially improve sweet corn's growth attributes and yield components. The increased grain protein content, total sugar content and reduced starch levels in sweet corn, under these systems, suggest a potential improvement in the nutritional quality of the crop. Therefore, adopting these technologies will enhance farmers' income and improve soil health.

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Authors' contributions

MR conducted the experiment and was responsible for writing the original manuscript draft. PKR conceptualized the research idea and provided overall direction and supervision throughout the study. MP co-conceptualized the study and guided the research execution and manuscript development. KKM performed the formal data analysis and contributed to critical revisions and corrections of the manuscript. NM supported the investigation and assisted with editing the manuscript. SD contributed to data collection and reviewed and refined the manuscript. SB was involved in the field investigation and provided input during the manuscript editing phase. MM helped in the experimental investigation and offered suggestions during manuscript revision. BRS participated in the research investigation and contributed to editorial improvements. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare no conflict of interest.

Ethical issues: None

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