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Performance of vegetables under different nutrient levels in sweet corn based intercropping systems

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Abstract
During the 2020 *rabi*, a field experiment titled "Nutrient Management in Sweet Corn based Vegetable Intercropping Systems" was conducted on the sandy clay loam soils of the wetland farm of S.V. Agricultural College, Tirupati, Andhra Pradesh. The experiment was designed with a split plot and replicated thrice. Main plots consisted of three intercropping systems *viz*., sweet corn + knol khol (I_1), sweet corn + radish (I_2) and sweet corn + onion (I_3) and sub plots with four nutrient levels *viz*., 100% RDF to sweet corn alone (N_1), 100% RDF to sweet corn + 75% RDF to inter crop (N_2), 100% RDF to sweet corn + 50% RDF to inter crop (N_3) and 100% RDF to sweet corn + 25% RDF to inter crop (N_4). All three intercrops performed better in terms of plant height, dry matter production and light interception, at all stages of observation with application of 100% RDF to sweet corn + 75% RDF to inter crop (N_2) followed by 100% RDF to sweet corn + 50% RDF to intercrop (N_3), 100% RDF to sweet corn + 25% RDF to intercrop (N_4) and 100% RDF to sweet corn alone (N_1), in order of descent. All intercrop yields was higher with application of 100% RDF to sweet corn + 75% RDF to intercrop (N_2) followed by 100% RDF to sweet corn + 50% RDF to intercrop (N_3), 100% RDF to sweet corn + 25% RDF to intercrop (N_4) and 100% RDF to sweet corn alone (N_1).

Keywords: Intercropping, RDF (Recommended dose of fertilizer), sweet corn, knol khol, radish, onion

1. Introduction
Due to a growth in population, India's need for food and nutrition has increased. The only way to satisfy the rising demand for food and nutrition is to increase crop yield per unit area using the limited amount of land and growing resources that are available. Combining crops is essential for improving output, maximizing the use of growing resources per unit area, and maintaining healthier soil. Sustainable agricultural output is crucial for today's Indian agriculture. Therefore, in order to achieve sustainability, we must consider every option for crop intensification with sustainable nutrition.

The third-most significant cereal crop worldwide and in India is maize. *Zea mays* L. *saccharata*, sometimes referred to as sweet corn or sugar corn, is a hybridized variety of maize created expressly to increase the sugar content. Sweet corn can be purchased frozen or canned for later use. It is also sold fresh, roasted or boiled. With rising demand for human consumption in and around major cities, fresh green cobs command premium prices. After the green cob harvest, nutritious green fodder is available, greatly increasing the economic benefits. Both domestically and internationally, Sweet Corn has enormous potential. Because it is a crop with a short growing season and only needs a little amount of area due to its single stem and upright growth habit, sweet corn is best suited for intercropping systems. It is suggested that sweet corn be intercropped with short-duration crops including legumes, leafy vegetables and other vegetables due to the demand for these crops. Additionally, it guarantees greater land occupancy and increases farmer profitability. Vegetables are the most important component of a diet that is balanced. They have the biologically valuable proteins, lipids, and carbohydrates, as well as vitamins, minerals, and dietary fibers, which gives them the name "Protective Food". In the growing of sweet corn, vegetables like knol khol, radish and onion can be used as intercrops. One of the more typical vegetables and a cool-season crop is knol khol. It is a good source of nutritional fiber as well as antioxidant vitamins C, E and carotene. The second intercrop radish, both the roots and the leaves are a significant source of nutrients, being high in ash, calcium, salt, phosphorus, potassium, and ascorbic acid as well as proteins, lipids, carbohydrates and fiber. Third intercrop is onion which is daily used vegetable in large quantity. Onions can be chopped raw and used in salads. Because they are so rich in vitamins,

minerals and antioxidants, onions are a nutrient-dense food.
Vegetable planting in India should now be intensified and expanded due to their quick growth and short duration. It serves as protection against crop failure in unusual years. Intercrops keep the soil fertile because they absorb nutrients from the top layers of the soil, reduce soil runoff and control weeds. In terms of offering protection and support, intercropping is more advantageous. Intercrops are chosen based on crop duration and growth rethyms. The productivity of maize largely depends on its nutrient requirement and management particularly that of nitrogen, phosphorus and potassium. Nutrient use efficiency of an individual crop in an intercrop is mostly lower than their respective sole crops. Some nutrients would be wasted during early growth stages of long-term crops, but they can utilize by an associated crop growing between the rows of intercropping system. Fertilizers are more efficiently used in an intercropping system, due to the increased amount of humus and the different rooting systems of crops, as well as differences in the amount of nutrients taken up. The intercropping system's fertilizer needs might range from only one crop to crops of many types being included. Therefore, it is necessary to determine an appropriate fertilizer dose for systems that intercrop vegetables and sweet corn, as well as to research the impact of nutrient levels on the development and output of sweet corn and related crops.

2. Material and Methods

The field experiment was conducted during *rabi*, 2020 at S.V. Agricultural college farm, Tirupati. The soil was sandy clay loam in texture, neutral in soil reaction, low in organic carbon and available nitrogen and medium in available phosphorus and available potassium. Sweet corn – ‘Sweet Gold-99’, knol khol - ‘Indam Early White’, radish - ‘Chetki Long’ and onion – KP onion were chosen for the study. The experiment was laid out in split plot design and replicated thrice with gross plot size of 6.0 m x 5.0 m and net plot size of 3.6 m x 4.2 m. The main plots comprised of three intercrops viz., sweet corn + knol khol (I_1), sweet corn + radish (I_2) and sweet corn + onion (I_3) and sub plots consisted of four nutrient level *viz*., 100% RDF to sweet corn alone (N_1), 100% RDF to sweet corn + 75% RDF to intercrop (N_2), 100% RDF to sweet corn + 50% RDF to intercrop (N_3) and 100% RDF to sweet corn + 25% RDF to intercrop (N_4). Sweet corn was sown @ 1 seed hill^{-1} with 60 cm x 20 cm spacing and intercrops *viz*., knol khol, radish and onion were in sweet corn inter rows space with 15 cm intra row spacing. Fertilizers were applied as per treatments. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash respectively. The recommended dose of fertilizer was for Sweet corn 120: 60 : 50 kg N, P_2O_5, K_2O ha^{-1}, for Knol khol 100 : 60 : 60 kg N, P_2O_5, K_2O ha^{-1}, for Radish 50 : 100 : 50 kg N, P_2O_5, K_2O ha^{-1} for Onion 80 : 50 : 80 kg N, P_2O_5, K_2O ha^{-1}.
Half dose of N, full dose of P_2O_5 and K_2O were applied as basal dose. After 30 DAS half dose of N was applied. Fertilizers were applied near rows of crops by band placement method. All the agronomic practices were carried out uniformly to raise the crop. Plant height was taken from the ground level to the tip of the last fully opened leaf at 20, 40 DAS and at harvest, averaged and expressed in cm. Five plants at random from the sampling rows leaving the extreme border rows were destructively sampled at 20, 40 DAS and at harvest for the estimation of dry matter production. The plant samples were initially shade dried and later dried in hot air oven at 60 °C, till a constant weight is attained and expressed in kg ha^{-1}. Light interception was recorded at 20 and 40 DAS. It was measured with quantum sensor at the top of sweet corn canopy and near the intercrops canopy and the mean value was expressed in per cent.

$$\text{Light interception(X)} = \frac{\text{Light interception at top of sweet corn canopy} - \text{Light interception near intercrops canopy}}{\text{Light interception at top of sweet corn canopy}} \text{X100}$$

Total biological yield was calculated by weighing the total dry matter (including economic yield) of net plot and expressed in kg ha^{-1}. Economic yield was calculated by weighing the total economically marketable product of intercrops produced in net plot and expressed in kg ha^{-1}. The biometric observations and yield on intercrops *i.e*., knol khol, radish and onion with regard to their plant height and dry matter production were recorded at periodical intervals *viz*., 20, 40 DAS and at harvest was not subjected to statistical analysis due to lack of feasibility. Hence, the mean values were furnished in tables.

3. Results and discussion

3.1 Plant height

The plant height of knol khol, radish and onion increased progressively from sowing to harvest. Sole crops of all vegetables recorded higher plant height than when it was intercropped with sweet corn. In intercropping among the different nutrient levels tried, application of 100% RDF to sweet corn + 75% RDF to intercrop (N_2) resulted in taller plants of knol khol, radish and onion. Shorter plants were produced with application of 100% RDF to sweet corn alone (N_1). Increased dose of nutrient to intercrop enabled the intercrops to absorb adequate amount of nutrients, which helps in better growth of plants and increased net photosynthesis. So plant height of intercrops was recorded higher with application of 100% RDF to sweet corn + 75% RDF to intercrop (N_2).

3.2 Dry matter production

The dry matter production of all vegetables increased progressively from sowing to harvest. Vegetables as sole crop produced higher dry matter compared to its intercropping with sweet corn. At 20, 40 DAS and at harvest, higher dry matter production of knol khol, radish and onion was recorded with application of 100% RDF to sweet corn + 75% RDF to intercrop (N_2), whereas 100% RDF to sweet corn alone (N_1) resulted in lower dry matter production in intercropping. Increased dose of nutrient to intercrop enabled the intercrops to absorb adequate amount of nutrients, which helps in better growth of plants and increased net photosynthesis.

3.3 Light Interception by Intercrops

At 20 DAS light interception by intercrops did not differed due to intercropping as well as nutrient levels, whereas at 40 DAS light interception was higher with sole crops of knol khol, radish and onion when compared to their intercropping systems. Light interception was higher with 100% RDF to sweet corn + 75% RDF to intercrop (N_2) this was followed by 100% RDF to sweet corn + 50% RDF to intercrop (N_3), 100% RDF to sweet corn + 25% RDF to intercrop (N_4) and 100% RDF to sweet corn alone (N_1) in order of descent.

Table 1: Plant height, drymatter production and light interception of knol khol as influenced by intercropping and nutrient levels

Treatment	Plant height (cm)			Dry matter production (kg ha^{-1})			Light interception (%)	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20DAS	40DAS
(Sweet corn + knolkhol) + N_1	10.5	22	30.5	50	1400	4275	35.0	60.5
(Sweet corn + knolkhol) + N_2	18.0	28.1	35.2	65	1783	5090	36.0	65.0
(Sweet corn + knolkhol) + N_3	15.6	26.5	34	63	1650	4875	35.6	63.5
(Sweet corn + knolkhol) + N_4	13.9	24.9	33.2	57	1550	4455	35.6	61.9
Sole knolkhol	19.0	30.0	38.0	120	3200	12500	40.0	68.0

Table 2: Plant height, drymatter production and light interception of radish as influenced by intercropping and nutrient levels

Treatment	Plant height (cm)			Dry matter production (kg ha^{-1})			Light interception (%)	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS
(Sweet corn + radish) + N_1	20.1	32.0	39.0	105	2000	5920	35.0	59.5
(Sweet corn + radish) + N_2	29.5	39.0	43.0	120	4949	7540	36.0	65.0
(Sweet corn + radish) + N_3	26.3	36.5	42.1	116	4000	6998	35.6	63.5
(Sweet corn + radish) + N_4	23.2	34.9	41.3	113	2950	6500	35.6	61.9
Sole radish	30.0	40.0	45.0	300	8900	13390	40.0	67.0

Table 3: Plant height, drymatter production and light interception of onion as influenced by intercropping and nutrient levels

Treatment	Plant height (cm)			Dry matter production (kg ha^{-1})			Light interception (%)	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS
(Sweet corn + onion) + N_1	13	30.3	38	50	1400	3800	35.0	60.5
(Sweet corn + onion) + N_2	18	35.6	42	60	1643	4500	36.0	63.0
(Sweet corn + onion) + N_3	16.5	33.5	40.5	56	1550	4250	35.6	62.5
(Sweet corn + onion) + N_4	15	32.3	39.5	53	1500	4000	35.6	60.9
Sole onion	20	38	55	100	3010	8500	40.0	68.0

Table 4: Yield of inter crops (kg ha^{-1}) as influenced by intercropping and nutrient levels

Treatments	Economic yield	Biological yield
(Sweet corn + Knol khol)+ N_1	4100	6450
(Sweet corn + Knol khol)+ N_2	5100	7080
(Sweet corn + Knol khol)+ N_3	4860	6890
(Sweet corn + Knol khol)+ N_4	4390	6500
(Sweet corn + radish)+ N_1	8390	11450
(Sweet corn + radish)+ N_2	9050	12560
(Sweet corn + radish)+ N_3	8780	12090
(Sweet corn + radish) + N_4	8650	11900
(Sweet corn + onion) + N_1	3700	4740
(Sweet corn + onion) + N_2	4400	5637
(Sweet corn + onion) + N_3	4220	5407
(Sweet corn + onion) + N_4	4000	5000
Sole knol khol	12500	16500
Sole radish	15650	20680
Sole onion	10450	13390
Sole sweet corn	6900	19900

*Note: N_1 - 100% RDF to sweet corn alone, N_2 - 100% RDF to sweet corn + 75% RDF to intercrop, N_3 - 100% RDF to sweet corn + 50% RDF to intercrop, N_4 - 100% RDF to sweet corn + 25% RDF to intercrop.

3.4 Economic and Biological Yield
Both economic and biological yield of knol khol, radish and onion under sole crop of unreplicated plot recorded was higher as compared to intercropping. Among nutrient levels, the highest economic and biological yield of all vegetables was recorded with application of 100% RDF to sweet corn + 75% RDF to intercrop (N_2) followed by that with 100% RDF to sweet corn + 50% RDF to intercrop (N_3) and100% RDF to sweet corn + 25% RDF to intercrop (N_4). Application of 100% RDF to sweet corn alone (N_1) resulted in lower economic and biological yield of knol khol, radish and onion. Higher yield of intercrops with application of 100% RDF to sweet corn + 75% RDF to intercrop (N_2) might be due to cumulative improvement in growth parameters and proper partitioning of photosynthates from source to sink.

4. Conclusion
In conclusion, the present investigation revealed that among the different nutrient levels application of 100% of RDF to sweet corn + 75% of RDF to intercrops was found to be suitable sweet corn based vegetable intercropping for Southern Agro-climatic zone of Andhra Pradesh.

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