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Correlation and regression of capsicum (*Capsicum annuum* var. *grossum* L.) as influenced by different N and K fertigation levels under poly house

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Abstract
The experiment was conducted in a naturally ventilated poly house at Water Technology Centre, Horticulture Farm, Rajendranagar, Hyderabad during rabi 2019-20 to find out the optimum N and K fertigation schedule for capsicum (*Capsicum annuum* var. *grossum* L.) crop. The experiment comprised of three replications in Factorial Randomized Block Design (FRBD) with two factors {i.e. N levels (4), K levels (3)} and twelve treatments *viz*; N fertigation levels of 0%, 120% (216 kg N ha^{-1}), 150% (270 kg N ha^{-1}), 180% (324 kg N ha^{-1}) and K fertigation levels of 0%, 80% (96 kg K_2O ha^{-1}), 100% (120 kg K_2O ha^{-1}) respectively. The 100% RDF was 180, 90 and 120 kg N, P_2O_5 and K_2O ha^{-1}. The source of N was urea, P was single super phosphate (SSP) and K was white muriate of potash (MOP). A common dose of P was applied to all the treatments. The N and K were applied through drip fertigation on every fourth day during different crop growth stages. In the fertigation programme, during crop establishment stage (10 DAT to 14 DAT), 10% of N and K_2O were applied in two splits. During vegetative stage, (15 to 46 DAT) 30% of N and 20% of K_2O were applied in eight splits. During flower initiation to fruit development (47 DAT to 74 DAT) 20% of N and K_2O were applied in seven splits. From fruit development till final harvesting stage (75 DAT to 154 DAT) 40% of N and 50% K_2O were applied in 20 splits. Then the fertigation schedule was completed in a total of 37 splits. The soil of the experimental site was sandy loam in texture with low in available nitrogen (166.5 kg ha^{-1}), medium in available phosphorus (81.1 kg P_2O_5 ha^{-1}) and low in available potassium (245.4 kg K_2O ha^{-1}). Irrigation was scheduled at 0.8 Epan. The total water applied to the crop was 414.8 mm. Based on correlation studies, it was noticed that plant height at 60 DAT, number of leaves $plant^{-1}$ at 150 DAT, number of branches $plant^{-1}$ at 90 DAT, LAI at 120 DAT, SPAD chlorophyll content at 60 DAT, dry matter production at final harvest and quality parameters strongly influencing the capsicum fruit yield. Also, nitrogen uptake at final harvest, phosphorous and potassium uptake at 120 DAT have highly influenced the fruit yield.

Keywords: Capsicum, nutrient uptake, N and K fertigation schedule, poly house, fertigation

Introduction
Capsicum (*Capsicum annuum* var. *grossum* L.) also referred to as sweet or bell pepper is a highly priced vegetable crop both in the domestic and international market. China is the major producer of capsicum and contributes 36 per cent of the worlds cultivated area with a production of 15.03 million tones. India contributes average annual production of 1.08 million tonnes from an area of 1.06 million hectare with a productivity of 1.12 t ha^{-1} Anonymous (2014). In Telangana it occupies an area of 150.2 ha, with 2873 metric tonnes production (Telangana State Horticulture Mission, 2018-19) [4]. The major capsicum producing states in India are Himachal Pradesh, Karnataka, Madhya Pradesh, Haryana, Jharkhand, Uttarakhand and Orissa. In poly houses through drip irrigation, the wetted soil volume and thus the active root zone is reduced under drippers and this small volume does not allow the addition of all plant nutrients needed by the plants. Rather, fertilizer needed is to be applied frequently and periodically in small amount with the each irrigation to ensure adequate supply of water and nutrient in the root zone. Therefore, as a result of the shift from surface irrigation to drip method of irrigation, fertigation becomes the most common fertilization in the irrigated agriculture. The use of soluble and compatible fertilizers, good quality irrigation water, and application of actual crop and water need are the prerequisite of the successful fertigation system. The use of poly houses for commercial vegetable production and maximum net returns has been most common in Western countries (Chandra, 1985) [1]. In Telangana since 2014-15 government has started encouraging protected cultivation under poly houses by farmers by providing financial support through subsidies. Presently the area under poly houses in Telangana is around 489.26 ha (Department of Horticulture, Telangana).

Nutrient uptake by capsicum at specific physiological stages of plant development is essential to developing a fertility program that maximizes nutrient uptake and accumulation to prevent periodic nutrient stress during the growth cycle (Hector *et al*., 1991) [3].

Materials and Methods

A field experiment was conducted at Horticultural Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* season of 2019-20. The study was initiated on Response of capsicum (*Capsicum annuum* var. *grossum* L.) to different nitrogen and potassium fertigation levels under poly house. The soil of the experimental site was sandy loam in texture with a pH of 7.6, electrical conductivity of 0.75 dS m^{-1}, medium in organic carbon (0.7%), low in available nitrogen (166.5 kg N ha^{-1}), medium in available phosphorus (81.1 kg P_2O_5 ha^{-1}) and low in available potassium (245.4 kg K_2O ha^{-1}).

Capsicum (pasarella) seeds were sown in pro trays on 5th August 2019 and 35 days old seedlings were transplanted on 10th September 2019 in a zig zag manner in a paired row pattern on raised beds. The experiment comprised of three replications in Factorial Randomized Block Design (FRBD) with two factors {N levels (4), K levels (3)} with twelve treatments *viz*; T_1 - Control (No N, K_2O), T_2 - N_0 (No fertilizer) + 80% RD of K_2O, T_3 - N_0 (No fertilizer) + 100% RD of K_2O, T_4 -120% RD of N + K_0 (No fertilizer), T_5 – 120% RD of N + 80% RD of K_2O, T_6 – 120% RD of N + 100% RD of K_2O, T_7 – 150% RD of N + K_0 (No fertilizer), T_8 -150% RD of N + 80% RD of K2O, T_9 – 150% RD of N + 100% RD of K_2O, T_{10} – 180% RD of N + K_0 (No fertilizer), T_{11} – 180% RD of N + 80% RD of K_2O, T_{12}- 180% RD of N + 100% RD of K_2O. {The 100% (RDF) was 180, 90 and 120 kg N, P_2O_5 and K_2O ha^{-1}} The source of N was urea, P was single super phosphate (SSP) and K was white muriate of potash (MOP). A common dose of phosphorous was applied uniformly to all the treatments at basal.

The nitrogen and potassium were applied through fertigation by ventury which was carried out at three day interval i.e., on every fourth day. In the fertigation programme during the crop establishment stage (10 DAT to 14 DAT), 10% of N and K_2O were applied in two splits. During the vegetative stage, (15 to 46 DAT) 30% of N and 20% of K_2O were applied in eight splits. During flower initiation to fruit development (47 DAT to 74 DAT) 20% of N and K_2O were applied in seven splits. From fruit development and colour formation stage onwards till final stage (75 DAT – 154 DAT) 40% of N and 50% K_2O were applied in 20 splits. Then the fertigation schedule was completed in a total of 37 splits. In addition, the crop had received a common dose of 12.5 t ha^{-1} vermicompost and 1.5 t ha^{-1} neem cake and 90 kg P_2O_5 ha and also waste decomposer, vermi wash sprays at every 15 days interval. Irrigation was scheduled based on 0.8 E pan and the total water applied through drip at 0.8 E pan (common to all the treatments) was 384.8 mm, water applied for nursery including special operations (bed preparation, wetting before transplanting) was 30.4 mm. The total water applied was 414.8 mm. The weight of mature fruits harvested from each picking was recorded till the final harvest and the total yield of fruits per hectare was computed and expressed in kg and tons per hectare.

The nutrients (N, P and K) uptake was calculated using nutrient concentration and dry matter yield or seed yield for that, plant samples and fruit samples at different crop growth stages were collected from each treatment, washed with tap water followed by 0.1 N HCl and distilled water. They were first dried under shade and then in hot air oven at 60^0C. The dried samples were ground in grinder and stored in butter paper covers and analyzed for N, P and K contents by adopting the standard procedures.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x Dry matter (kg ha}^{-1})}{100}$$

$$\text{Nutrient requirement (kg ha}^{-1}\text{ day}^{-1}) = \frac{\text{Total uptake upto particular stage (i.e 0-30/30-60/60-90/90-120/120-final harvest)}}{\text{Uptake of particular month}}$$

Results and Discussion

Correlations

The data regarding correlations is presented in Table 1. In general the correlations indicated that the fruit yield is positively correlated with growth parameters, yield attributes, quality parameters and nutrient uptake. Significant positive correlation was noticed between fruit yield and plant height of capsicum. The highest correlation was noticed at 60 DAT (0.943) followed by 90 DAT (0.915), 150 DAT (0.909), final harvest (0.889), 120 DAT (0.863), 30 DAT (0.797).

The number of leaves $plant^{-1}$ was significantly correlated with yield. The highest correlation was noticed at 150 DAT (0.962), followed by final harvest (0.956), 90 DAT (0.948), 30 DAT (0.939), 120 DAT (0.930), 60 DAT (0.880).

Regarding the number of branches $plant^{-1}$ the highest correlation was noticed at 90 DAT (0.971) followed by 120 DAT (0.963), final harvest (0.945), 150 DAT (0.944), 60 DAT (0.908), 30 DAT (0.817).

The LAI was significantly correlated with fruit yield at all the stages. The highest correlation (0.964) was noticed at 120 DAT, followed by 90 DAT (0.957), 6 DAT (0.951), 150 DAT (0.938), final harvest (0.898), 30 DAT (0.896).

Significant positive correlation was noticed between fruit yield and SPAD chlorophyll meter readings of capsicum. The highest correlation was noticed at 60 DAT (0.916) followed by 120 DAT (0.913), 150 DAT (0.904), final harvest (0.899), 90 DAT (0.888), 30 DAT (0.870).

Significant positive correlation was noticed between fruit yield and dry matter at all the growth stages and the highest correlation was noticed at final harvest (0.982) followed by 150 DAT (0.965), 30 DAT (0.962), 60 DAT (0.957), 90 DAT (0.941), 120 DAT (0.930) respectively.

The correlation between yield and yield attributes were found to be significant *viz*., mean fruit length (0.909), mean fruit width (0.923), mean pericarp thickness (0.924), mean average fruit weight (0.987), total number of fruits $plant^{-1}$ (sum of six pickings) (0.760) respectively.

The data on correlation between yield and quality parameters revealed that there was a significant positive correlation *viz*., mean brix (0.942), mean oleoresin (0.944), mean capsanthin

(0.936), mean ascorbic acid (0.940), mean capsaicin (0.834) respectively.

The total nitrogen uptake was significantly correlated with fruit yield and the highest correlation was noticed at final harvest (0.961) followed by 90 DAT (0.959), 60 DAT (0.957), 120 DAT (0.954), 30 DAT (0.948).

The total phosphorous uptake was significantly correlated with fruit yield and the highest correlation was noticed at 120 DAT (0.979) followed by 90 DAT (0.971), 30 DAT (0.963), 60 (0.951), and final harvest (0.936).

Significant positive correlation was noticed between fruit yield and total potassium uptake. The highest correlation was noticed at 120 DAT (0.956) followed by final harvest (0.940) and 30 DAT (0.932), 60 DAT (0.903), 90 DAT (0.749).

Regression

The dependence of yield on plant height was evident from significant (P=0.01) and positive correlation between yield versus plant height. Determination coefficient R^2 was 0.922, 0.881 and 0.831 at 60, 90, 120 DAT respectively.

Significant positive correlation was observed between fruit yield and number of branches plant^{-1} which was evident from significant (P=0.01) and positive correlation. Determination coefficient (R^2) was 0.943, 0.936 at 90 and 120 DAT respectively.

There existed a significant positive correlation between yield and number of leaves plant^{-1}. This was also evident from the determination coefficient R^2 = 0.895, 0.901, 0.879 and 0.938 at 30, 90, 120 and 150 DAT respectively.

The dependence of yield on LAI was evident from significant (P=0.01) and positive correlation between yield versus LAI and the highest was noticed at 120 DAT. Determination coefficient R^2 was 0.857, 0.922, 0.937 and 0.918 at 30, 60, 120 and 150 DAT respectively.

The dependence of dry matter on fresh fruit yield of capsicum was studied and showed significant (P=0.01) positive correlation. It was also evident from the determination coefficient (R^2) which showed 0.917, 0.909, 0.925 and 0.927 values at 30, 90, 120 and at final harvest respectively.

There existed a significant positive correlation between average fruit weight and yield. Determination coefficient (R^2) was calculated as 0.988 which showed increase in fruit yield with increase in the mean fruit weight**.**

Also, the determination coefficient R^2 revealed the same with significant (P = 0.01) and positive relationship between yield and mean fruit length.

Determination coefficient (R^2) calculated for the dependence of yield on mean fruit width for capsicum and it was significant (P=0.01) with R^2 = 0.872.

Significant positive correlation of fruit yield versus mean pericarp thickness was noticed and it was evident from significant (P=0.01) and positive correlation. Determination coefficient (R^2 =0.876) calculated for the relationship between yield versus mean pericarp thickness showed increasing trend.

Number of fruits plant^{-1} and fruit yield showed positive correlation with a determination coefficient (R^2=0.784)

Table 1: Correlation studies between fruit yield Vs growth, yield, quality parameters and nutrient uptake of capsicum under poly house during *rabi* 2019-20

S. No.	Parameter	DAT	r^2 value
			Green
1.	Plant height	30 DAT	0.797**
		60 DAT	0.943 **
		90 DAT	0.915**
		120 DAT	0.863**
		150 DAT	0.909 **
		Final harvest	0.889 **
2.	Number of leaves plant^{-1}	30 DAT	0.939**
		60 DAT	0.880**
		90 DAT	0.948**
		120 DAT	0.930 **
		150 DAT	0.962 **
		Final harvest	0.956 **
3.	Number of branches plant^{-1}	30 DAT	0.817 **
		60 DAT	0.908**
		90 DAT	0.971**
		120 DAT	0.963 **
		150 DAT	0.944 **
		Final harvest	0.945 **
4.	LAI	30 DAT	0.896**
		60 DAT	0.951**
		90 DAT	0.957 **
		120 DAT	0.964 **
		150 DAT	0.938 **
		Final harvest	0.898**
5.	SPAD chlorophyll meter readings	30 DAT	0.870**
		60 DAT	0.916**
		90 DAT	0.888 **
		120 DAT	0.913 **
		150 DAT	0.904 **
		Final harvest	0.899 **
6.	Dry matter (kg ha^{-1})	30 DAT	0.962**
		60 DAT	0.957**

		90 DAT	0.941 **
		120 DAT	0.930 **
		150 DAT	0.965 **
		Final harvest	0.982 **
7.	Mean fruit length (cm)	Mean of first, third and fifth picking	0.909 **
8.	Mean fruit width (cm)	Mean of first, third and fifth picking	0.923**
9.	Pericarp thickness (mm)	Mean of first, third and fifth picking	0.924 **
10.	Average fruit weight (g)	Mean of six pickings	0.987**
11.	Total number of fruits plant-1	Sum of six pickings	0.760**
12.	Brix	Mean of first, third and fifth picking	0.942 **
13.	Oleoresin	Mean of first, third and fifth picking	0.944**
14.	Capsanthin	Mean of first, third and fifth picking	0.936 **
15.	Ascorbic acid	Mean of first, third and fifth picking	0.940 **
16.	Capsaicin	Mean of first, third and fifth picking	0.834 **
17.	Total nitrogen uptake (kg ha-1)	30 DAT	0.948 **
		60 DAT	0.957 **
		90 DAT	0.959 **
		120 DAT	0.954 **
		Final harvest	0.961 **
18.	Total phosphorous uptake (kg ha-1)	30 DAT	0.963**
		60 DAT	0.951**
		90 DAT	0.971 **
		120 DAT	0.979**
		Final harvest	0.936 **
19.	Total potassium uptake (kg ha-1)	30 DAT	0.932**
		60 DAT	0.903 **
		90 DAT	0.749**
		120 DAT	0.956**
		Final harvest	0.940**

Note: (*) - Significant at 95% and (**) - significant at 99% of confidence (n-2) = 12-2=10
At n = 10, r^2: Equal or above of 0.57596 at 95% and 0.70789 at 99% level of significance.

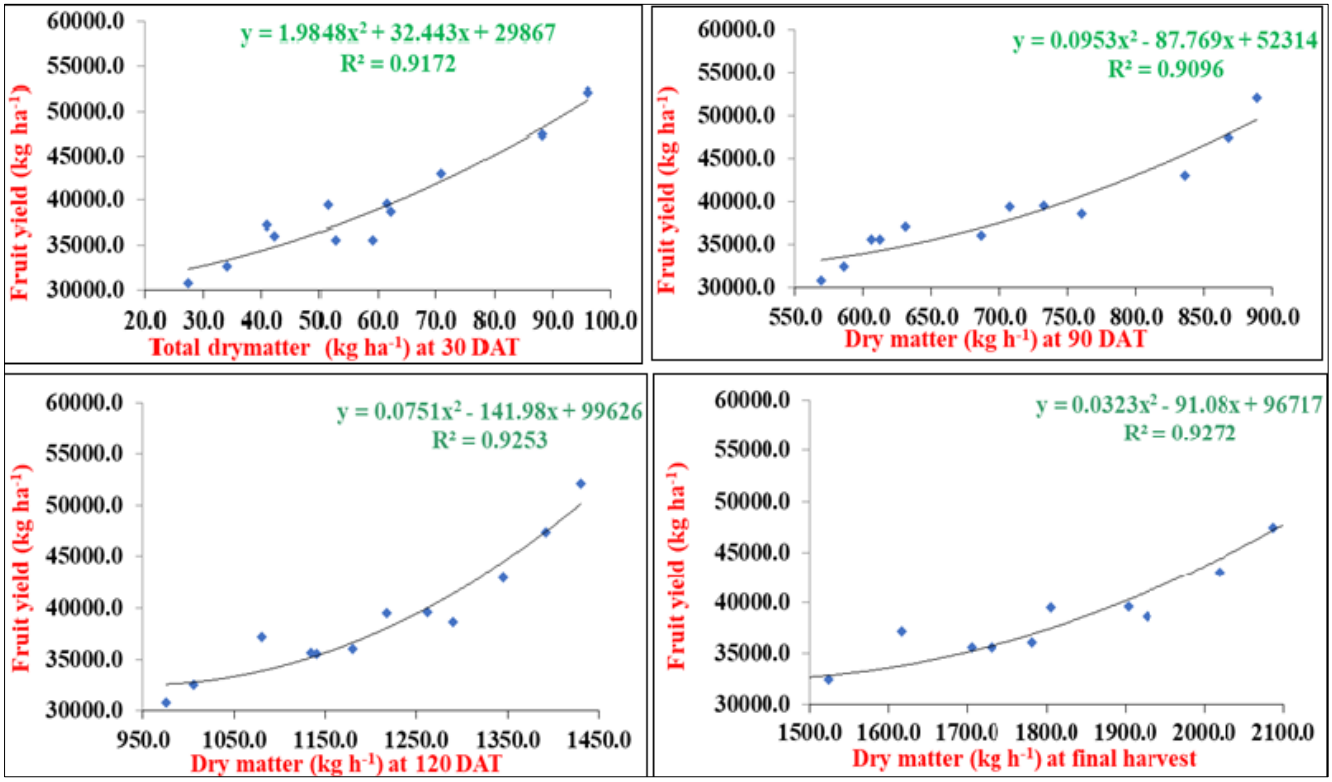

Fig 1: Regression of capsicum fruit yield (kg ha^{-1}) with total dry matter at 30, 90, 120 DAT and at final harvest

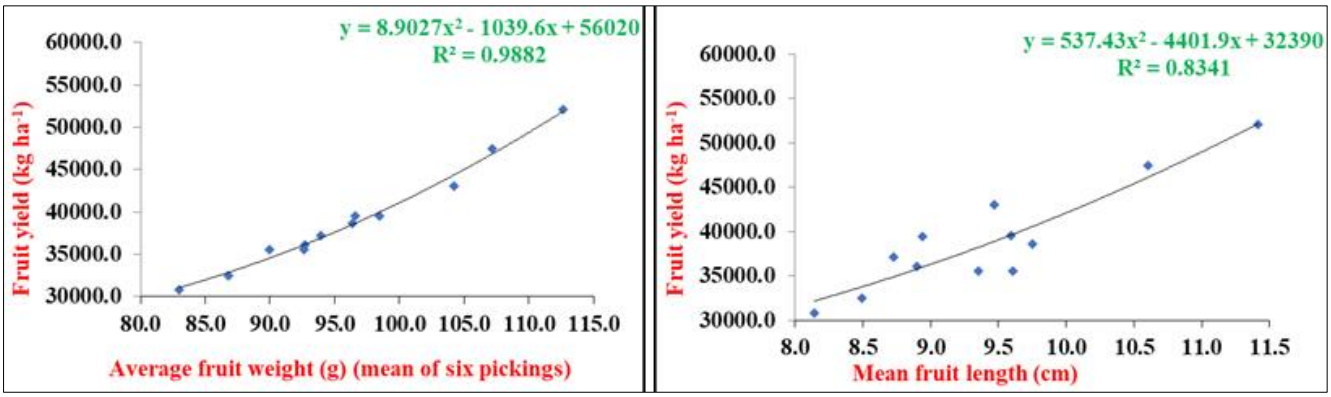

Fig 2: Regression of capsicum fruit yield (kg ha^{-1}) with overall mean fruit weight (mean of six pickings), and mean fruit length (cm)

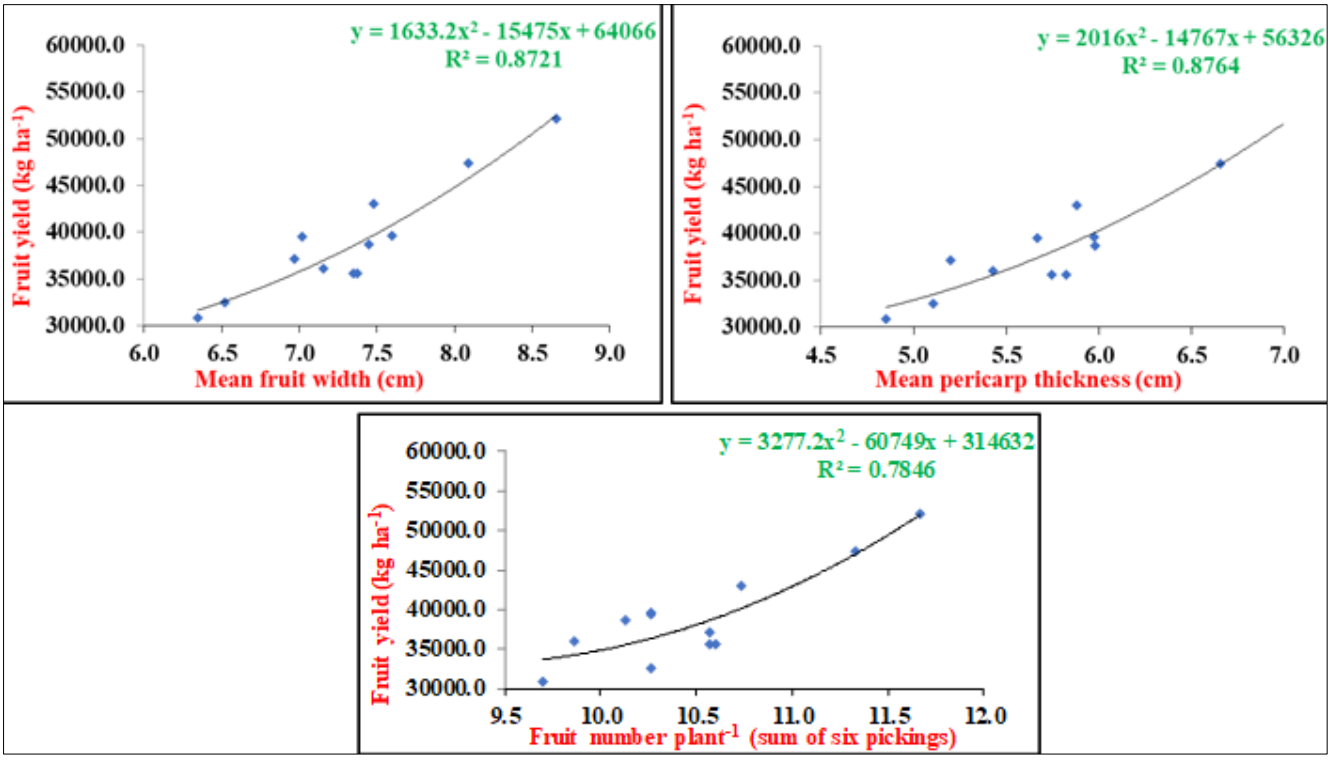

Fig 3: Regression of capsicum fruit yield (kg ha^{-1}) with mean fruit width (cm), mean pericarp thickness (mm) number of fruits plant^{-1} (sum of six pickings)

Conclusion

Based on correlation studies, it was noticed that plant height at 60 DAT, number of leaves plant^{-1} at 150 DAT, number of branches plant^{-1} at 90 DAT, LAI at 120 DAT, SPAD chlorophyll content at 60 DAT, dry matter production at final harvest and quality parameters strongly influencing the capsicum fruit yield. Also, nitrogen uptake at final harvest, phosphorous and potassium uptake at 120 DAT have highly influenced the fruit yield.

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