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Krishna D Kurubetta
Assistant Professor of
Agronomy, HRES, Devihosur,
Haveri, Karnataka, India

Abdul Kareem M
Assistant Professor of
Agronomy, HRES, Devihosur,
Haveri, Karnataka, India

RK Mesta
Assistant Professor of
Agronomy, HRES, Devihosur,
Haveri, Karnataka, India

TB Allolli
Assistant Professor of
Agronomy, HRES, Devihosur,
Haveri, Karnataka, India

MH Tatagar
Assistant Professor of
Agronomy, HRES, Devihosur,
Haveri, Karnataka, India

Sweta K
Assistant Professor of
Agronomy, HRES, Devihosur,
Haveri, Karnataka, India

Corresponding Author:
Sujata P
Msc. Horticulture (CIB), College
of Horticulture, Sirsi, Banavasi
Road, Sirsi (T) Uttar Kannada
(D), India

Effect of secondary nutrients on yield, quality and economics of dry chilli (*Capsicum annuum* L.)

Krishna D Kurubetta, Abdul Kareem M, RK Mesta, TB Allolli, MH Tatagar and Sweta K

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Abstract

The field experiment was laid out at Horticulture Research and Extension Station, Devihosur, Haveri, Karnataka during *kharif* season of three years (2016, 2017 and 2018) on medium deep black clay soil. The treatment (T7) applied with RDF along with Ca+Mg+S @ 25+25+25 kg/ha recorded significantly higher dry chilli yield of 1056, 571 and 799 kg/ha during the year 2016, 2017 and 2018, respectively, compared to the rest of the treatments. Significantly highest gross returns (Rs. 1,09,215/ha), net returns (Rs. 73,165/ha) and B:C ratio (3.03) was found with the treatment (T7) Ca+Mg+S @ 25+25+25 kg/ha compared to other treatments.

Keywords: Dry chilli, secondary nutrients, byadagi chilli, economics

Introduction

India is the largest producer, consumer and exporter of chilli, which contributes to 25% of total world’s production. In India the most important chilli growing states are Karnataka, Tamil Nadu, Odisha, Maharashtra, Rajasthan and West Bengal. Chilli being a long duration crop, requires proper manuring and fertilizing in the surface soil is because of its shallow root system, for attaining high yields and quality produce (Bidari, 2000) [1]. Chillies are excellent source of vitamin A, C and E with minerals like molybdenum, magnesium, potassium and copper. It is an essential ingredient of Indian curry, which is characterized by tempting colour and exciting pungency. It is predominantly popular for its green pungent fruits, which is used for culinary purpose. It is commercially important for the two qualities, the red colour due to the pigment capsanthin and the biting taste due to the chemical constituent capsaicin. Adequate and balanced fertilizer management in association with manures is very much essential to exploit the full yield potential of Chilli (Alima Shabir *et. al.*, 2016). After the green revolution, increase in production was achieved at the cost of soil health. It has been proved that indiscriminate use of inorganic fertilizers results in decrease in soil fertility and increase in soil acidity with depletion of organic humus content in addition to poor crop quality. Use of organic manures to meet the nutrient requirements of crop would be an inevitable practice in the years to come for sustainable agriculture since organic manures not only improve the physical, chemical and biological properties of soil. Eco friendly, scientific method of crop production envisages use of organics in the soil as a source of nutrients (Kurubetta *et. al.*, 2017). Inorganic nutrients play an important, direct role in yield and its attributes, as well as uptake of nutrients. However, use of organics along with inorganic nutrients not only helps increase the yield of crops, but also acts as a storehouse of nutrients, besides improving physical condition of the soil and quality of the produce. The escalating cost of fertilizers, their hazardous polluting effects on environment and quality of the produce, there is a growing awareness among the farming community of the advantages of organic fertilizers. Therefore the present investigation was undertaken to study the effect of organic, inorganic and bio fertilizers for yield and quality improvement in chilli.

Calcium, magnesium and sulfur are essential plant nutrients. They are called “secondary” nutrients because plants require them in smaller quantities than nitrogen, phosphorus, and potassium. On the other hand, plants require these nutrients in larger quantities than the “micronutrients” such as boron and molybdenum. Calcium, magnesium, and sulfur are generally adequate in the soils of favorable pH and organic matter levels. They affect pH when applied to the soil. Calcium and magnesium both increase soil pH, but sulfur from some sources reduces soil pH. Compounds containing one or more of these nutrients are often used as soil amendments rather than strictly as suppliers of plant nutrition.

Materials and Methods

The field experiment was laid out at Horticulture Research and Extension Station, Devihosur, Haveri, Karnataka during *kharif* season of three years (2016, 2017 and 2018) on medium deep black clay soil in a Randomized Block Design consists of thirteen treatments combinations and are replicated thrice for the study. The gross and net plot sizes of the experiment were 6.0 m X 4.8 m and 5.4 m X 4.2 m respectively. The standard agronomic practices were followed during experimentation. The recommended doses of inorganic fertilizers (NPK) @ 100:50:50 kg/ha was applied along with various doses of secondary nutrients as per the treatments. The data on dry chilli yield, quality and economics were recorded. The treatment details are as follows; T1-RDF+ Ca @25kg/ha, T2-RDF+ Ca @50kg/ha, T3-RDF+ Mg @25kg/ha, T4-RDF+ Mg @50kg/ha, T5-RDF+ S @50kg/ha, T6-RDF+ S @25kg/ha, T7-RDF+ Ca +Mg+S@25+25+25 kg/ha, T8-RDF+ Ca +Mg+S@25+50+50 kg/ha, T9- RDF+ Ca +Mg+S@25+50+25 kg/ha, T10-RDF+ Ca +Mg+S@50+50+50 kg/ha, T11-RDF + Ca +Mg+S@50+25+25 kg/ha, T12-RDF+ Ca +Mg+S@50+50+25 kg/ha and T13-RDF (100:50:50 NPK kg/ha)

a. Calcium

The primary function of calcium in plant growth is to provide structural support to cell walls. Calcium also serves as a secondary messenger when plants are physically or biochemically stressed. Soils with favorable pH levels are normally not deficient in calcium. Acid soils with calcium contents of 500 pounds per acre or less are deficient for legumes, especially peanuts, alfalfa, clovers, and soybeans. At this level, limited root system crops such as tomatoes, peppers, and cucurbit would also need additional calcium. Soluble calcium is available as the Ca^{2+} ion and is needed for peanuts at pegging time and for peppers and tomatoes to prevent blossom end rot. Available calcium can be lost from the soil when it is (a) dissolved and removed in drainage water, (b) removed by plants, (c) absorbed by soil organisms, (d) leached from the soil in rain water, or (e) absorbed by clay particles. Deficiency symptoms include death at the growing point, abnormally dark green foliage, weakened stems, shedding flowers, and any combination of these. Limestone is the primary source of calcium. Other common sources include basic slag, gypsum, hydrated lime, and burned lime. Hydrated lime and burned lime contain more readily available calcium than do basic slag and gypsum. Gypsum does not affect soil pH even though it contains calcium.

b. Magnesium

Magnesium is adequate for crop production in most soils except the coarse sandy soils of the Coastal Plains and the heavy dark clays. Magnesium is absorbed as the Mg^{2+} ion and is mobile in plants, moving from the older to the younger leaves. It leaches from the soil like calcium and potassium. Magnesium is the central atom amid four nitrogen atoms in the chlorophyll molecule, so it is involved in photosynthesis. It serves as an activator for many enzymes required in plant growth processes and stabilizes the nucleic acids. Interveinal chlorosis is a deficiency symptom in crops such as legumes, corn, sorghum, cotton, and certain leafy vegetables. (Interveinal chlorosis is a yellowing between the veins while the veins remain green.) The leaves may become pink to light red and may curl upward along the margins (Plate 1). To correct magnesium deficiency in soil, use dolomitic lime when lime is needed; use soluble sources of magnesium when lime is not needed. The most common soluble sources of magnesium to use as fertilizer are magnesium sulfate (containing 10% Mg and 14% S, also known as Epsom salt), sulphate of potash magnesia (containing 11.2% Mg, 22% S, and 22% K_2O, commercially sold as K-Mag), and magnesium oxide (containing 55% Mg, also known as magnesia).

c. Sulfur

Sulfur is needed in fairly large quantities by most crops. It is an essential building block in chlorophyll development and protein synthesis. Sulfur is required by the rhizobia bacteria in legumes for nitrogen fixation. In general, crops remove about as much sulfur as they do phosphorus. The sulfate ion, SO_4, is the form primarily absorbed by plants. Sulfate is soluble and is easily lost from soils by leaching. As sulfate is leached down into soil, it accumulates in heavier (higher clay content) subsoils. For this reason, testing for sulfur in topsoil is unreliable for predicting sulfur availability during a long growing season. Many coarse-textured, sandy soils and low organic matter, silty soils are sulfur deficient for crop production. Many acid soils contain metallic sulfides that release sulfur as weathering occurs. Sulfur deficiency symptoms show on young leaves first. The leaves appear pale green to yellow. The plants are spindly and small with retarded growth and delayed fruiting. For a rapid correction of a deficiency (Plate 1), use one of the readily available sulfate sources. There are many sources of fertilizer sulfur available. Organic matter is the source of organic sulfur compounds and is the main source of soil sulfur in most of the soils. Other sources of sulfur are rainfall and fertilizers that contain sulfur. Some readily available sources include ammonium sulfate (21% N and 24% S), potassium sulfate (50% K_20 and 17.6% S), gypsum (32.6% CaO and 16.8% S), and zinc sulfate (36.4% Zn and 17.8% S). There are several other sulfate sources as well as less available sources of sulfur in the elemental or sulfide form. Elemental sulfur is a good acidifying agent. An application of 500 pounds of sulfur per acre on sandy loam soil reduces the pH from 7.5 to 6.5. It takes about 3 pounds of lime to neutralize the acidity formed by 1 pound of sulfur.

Calcium Deficiency Magnesium Deficiency Sulphur Deficiency

Plate 1: Deficiency symptoms of secondary nutrients in chilli

Results and Discussion

The yield of dry chilli differed significantly for the secondary nutrients during all the years (2016, 2017 & 2018) of the experimentation (Table No.1). Among all the treatments, the treatment (T7) applied with RDF along with Ca+Mg+S @ 25+25+25 kg/ha (respectively) recorded significantly higher dry chilli yield of 1056, 571 and 799 kg/ha during the year 2016, 2017 and 2018, respectively compared to the rest of the treatments. However, it is found on par with the treatment (T8) RDF+ Ca+Mg+S @25+50+50 kg/ha during all the years. The similar response was also noticed for the three years pooled dry chilli yield. The significantly highest pooled yield was noticed with treatment T7 compared to other treatments. The increased yield during all three years was mainly due to increased growth performance (Krishna *et. al.*, 2018) [4] and better physiological activity due to secondary nutrients which promoted the plant for increased transmission of assimilates from source to sink. The each secondary nutrient @ of 25 kg/ha was found to be optimum to increase the yield without having any toxic symptoms on the plant. Similar results of response of chilli for secondary and micro nutrients were also noticed by Shivaprasad *et al.*, 2009 [5] and Hussain *et al.*, 1989 [2].

The quality parameter of dry chilli *i.e.* color was differed significantly for the secondary nutrients (Table 2). The pooled result of all the three years revealed that, the highest fruit color of 205 ASTA units was observed for the treatment (T8) RDF+ Ca+Mg+S @25+50+50 kg/ha compared to other treatments. However, it is found on par with the treatment (T7) Ca+Mg+S @ 25+25+25 kg/ha. Other fruit quality parameters like capsaicin (%) and oleoresin (%) were found statistically non-significant. However, numerically higher capsaicin (%) and oleoresin (%) content was noticed with the treatment T7 and T8 compared to rest of the treatments.

The pooled results of three years of gross returns, net returns and B:C ratio were also differed significantly for the treatments (Table 3). Significantly highest gross returns (Rs. 1,09,215/ha), net returns (Rs. 73,165/ha) and B:C ratio (3.03) was found with the treatment (T7) Ca+Mg+S @ 25+25+25 kg/ha compared to other treatments. However it was found onpar with treatment (T8) RDF+ Ca+Mg+S @25+50+50 kg/ha.

Table 1: Effect of secondary nutrients on dry fruit yield (kg/ha) of chilli over the years (2016, 2017, 2018 & Pooled)

Treatments	Dry fruit yield per ha (kg)			
	2016	**2017**	**2018**	**Pooled**
T1- RDF+ Ca @ 25 kg/ha	790	427	589	602
T2- RDF+ Ca @ 50 kg/ha	912	493	749	718
T3- RDF+ Mg @ 25 kg/ha	921	498	541	653
T4- RDF+ Mg @ 50 kg/ha	599	324	567	497
T5- RDF+ S @ 50 kg/ha	840	454	679	658
T6- RDF+ S @ 25 kg/ha	904	510	678	697
T7- RDF+ Ca +Mg+S @ 25+25+25 kg/ha	1056	571	799	809
T8- RDF+ Ca +Mg+S @ 25+50+50 kg/ha	979	529	828	779
T9- RDF+ Ca +Mg+S @ 25+50+25 kg/ha	697	377	811	628
T10- RDF+ Ca +Mg+S @ 50+50+50 kg/ha	831	449	803	694
T11- RDF+ Ca +Mg+S @ 50+25+25 kg/ha	936	506	724	722
T12- RDF+ Ca +Mg+S @ 50+50+25 kg/ha	851	460	758	690
T13- RDF (100:50:50 NPK kg/ha)	951	514	512	659
S.Em +	26.12	17.5	15.8	19.6
C. D @ 5%	79	51	46	57
C.V (%)	14	14.2	13.8	14.1

Table 2: Effect of secondary nutrients on fruit quality of chilli over the years (2016, 2017, 2018 & Pooled)

Treatments	Color (ASTA)				Capsaicin (%)				Oleoresin (%)			
	2016	**2017**	**2018**	**Pooled**	**2016**	**2017**	**2018**	**Pooled**	**2016**	**2017**	**2018**	**Pooled**
T1- RDF+Ca@25kg/ha	171	163	173	169	0.93	0.91	0.95	0.93	6.89	6.86	6.93	6.89
T2- RDF+Ca@50kg/ha	168	164	172	168	0.91	0.87	0.92	0.90	6.92	6.88	6.94	6.91
T3- RDF+Mg@25kg/ha	158	152	157	156	0.93	0.90	0.95	0.93	7.18	7.01	6.98	7.06
T4- RDF+Mg@50 kg/ha	191	186	194	190	0.93	0.90	0.95	0.93	6.88	7.02	6.92	6.94
T5- RDF+S@50kg/ha	188	183	191	187	0.92	0.89	0.94	0.92	6.91	6.88	6.95	6.91
T6- RDF+S@25kg/ha	179	174	182	178	0.92	0.89	0.94	0.92	6.91	6.88	6.95	6.91
T7- RDF+Ca+Mg+S@25+25+25kg/ha	204	199	207	203	0.93	0.90	0.95	0.93	7.58	7.55	7.62	7.58
T8-RDF+Ca+Mg+S@25+50+50kg/ha	206	201	209	205	0.92	0.89	0.94	0.92	7.58	7.55	7.62	7.58
T9- RDF+ Ca +Mg+S @ 25+50+25 kg/ha	184	179	187	183	0.91	0.88	0.93	0.91	7.55	7.52	7.29	7.45
T10- RDF+ Ca +Mg+S @ 50+50+50 kg/ha	188	200	199	196	0.93	0.90	0.95	0.93	7.42	6.99	7.46	7.29
T11- RDF+ Ca +Mg+S @ 50+25+25 kg/ha	191	186	194	190	0.92	0.89	0.93	0.91	6.33	7.30	7.37	7.00
T12- RDF+ Ca +Mg+S @ 50+50+25 kg/ha	193	208	199	200	0.92	0.88	0.94	0.91	6.91	6.88	6.95	6.91
T13- RDF (100:50:50 NPK kg/ha)	193	188	196	192	0.92	0.89	0.93	0.91	6.91	6.88	6.95	6.91
S.Em +	0.8	0.9	0.76	0.85	0.12	0.18	0.15	0.16	0.45	0.51	0.55	0.52
C. D @ 5%	2.5	2.8	2.3	2.4	NS	NS	NS	NS	NS	NS	NS	NS
C.V (%)	8.6	9.6	7.1	8.9	9.2	7.2	8.2	8.4	10.5	9.5	8.2	9.1

Table 2: Effect of secondary nutrients on yield, gross returns, net returns and B:C ratio of chilli (Three years Pooled)

Treatments	Yield (kg/ha)	Gross Return (Rs./ha)	Net Return (Rs./ha)	B:C
T1- RDF+ Ca @25kg/ha	602	81270	46620	2.35
T2- RDF+ Ca @50kg/ha	718	96930	61080	2.70
T3- RDF+ Mg @25kg/ha	653	88155	53905	2.57
T4- RDF+ Mg @50kg/ha	497	67095	32045	1.91
T5- RDF+ S @50kg/ha	658	88830	54180	2.56
T6- RDF+ S @25kg/ha	697	94095	60045	2.76
T7- RDF+ Ca +Mg+S@25+25+25 kg/ha	809	109215	73165	3.03
T8- RDF+ Ca +Mg+S@25+50+50 kg/ha	779	105165	67715	2.81
T9- RDF+ Ca +Mg+S@25+50+25 kg/ha	628	84780	47930	2.30
T10- RDF+ Ca +Mg+S@50+50+50 kg/ha	694	93690	55040	2.42
T11- RDF+ Ca +Mg+S@50+25+25 kg/ha	722	97470	60220	2.62
T12- RDF+ Ca +Mg+S@50+50+25 kg/ha	690	93150	55100	2.45
T13- RDF (100:50:50 NPK kg/ha)	659	88965	55515	2.66
S.Em ±	21.8	3659.5	4257.4	0.084
C. D @ 5%	65.0	10600	9800	0.25
C.V (%)	11.8	14.0	15.0	11.0

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