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Studies on the effect of integrated nutrient management on growth, flowering, yield and quality of chilli var. Beladanga in saline belt of West Bengal

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Abstract
Beladanga was chosen for this experiment on the basis of best performance in Saline Belt. This experiment was conducted with the objectives to identify the best source of nitrogen from organic and inorganic fertilizer, and their combinations for increasing growth, flowering fruit yield and quality of chilli. The experiment was designed with nineteen treatments and three replication. The selected manures were Cowdung manure, Neem cake, Poultry manure, Vermicompost, Phosphocompost and Mustard cake, easily available in this area were applied in different combinations with inorganic fertilizer (Urea) at three levels(25%, 50%, and 75%) to enrich growing media. Increasing dose of N (25 to 75%) from mustard cake induced flower early by 2-3 days with combination of urea. Maximum delay in flowering by 4 days were observed, when plants were manured with 50% N from cowdung and Phosphocompost with 50% N from urea. It was observed that all levels of nitrogen received from vermicompost showed very pronounced effect on flower production (250.20-260.20) of chilli. But best combination was obtained with 50% N from both the sources (Vermicompost and Urea) and produced 42.19% more flowers (260.20) as compared to control and lowest (120.60) no. of flowers was obtained with the combination of 25% N from Phosphocompost along with 75% N from Urea. Regarding no. of fruits per plant, the best combination of urea and vermicompost at 50% obtained 51.55% more fruits per plant (161) over control. Weight of individual fruit was highest (7 g) under treatment with 50% nitrogen both from vermicompost and urea and lowest weight was found under control (4.0g) i.e. without application of nitrogen. The plant produced average highest yield (1127.0g/plant) when treated with 50% N from VC + 50% N from Urea, whereas, lowest (312.0g/plant) performance was observed with the plant without nitrogen in control. During the Second year of the experiment, almost same trend was found in above mention parameters. The combination played an important role in vegetative growth and yield i.e. increased number of fruits per plant by 55.55%, increased weight of individual fruit by 42.80% and increased yield per plant by 261.21% more than control (without Nitrogen). The highest B:C ratio of 5.52 was also obtained in this combination, indicating the maximum economic benefit. But, regarding the quality aspect, Neem cake as a source of nitrogen @ 25% played a vital role for improvement of capsaicin and ascorbic acid content in the fruit *viz*. capsaicin content, 114.20mg/g of dry biomass and ascorbic acid content, 185.50 mg/100g of green edible chilli and same trend was found in the second year also.

Keywords: Chilli, INM, growth, flowering, yield, quality, Beladanga, saline belt

Introduction
Chilli is an important crop in the saline belt of West Bengal particularly in the districts and coastal areas like South 24 Parganas and Purba Medinipur districts. However, different well-known local cultivars are grown by the farmers of these areas, but their yield potentiality under the saline condition is unknown to us. Systematic evaluation of available local cultivars is, therefore, necessary to identify the more efficient/best cultivar suitable for this region. Moreover, chilli is predominantly used for its green pungent fruits, where excessive use of inorganic source of nutrients for its cultivation may invite health problem. Therefore, inclusion of organic source of nutrients more than usual inorganic sources is essential consideration. Integrated nutrient management with vermicomposting, green manuring or application of biofertilizers also showed a significant response on chillies (Nath *et al*., 2008) [4].

Materials and Methods
The present investigation was carried out in consecutive two seasons at open cultivable farmers' field at Dakshin Paikbar mouza under "Deshapran Block" (Contai –II) in the Disrtict

of Purba Medinipur, West Bengal for "Studies on the effect of integrated nutrient management on growth, flowering and yield of chilli var. Beladanga in Saline Belt of West Bengal".

The selected chilli cultivar Beladanga was found to be the best for saline soil and the results obtained from the varietal evaluation. Therefore, the variety Beladanga was selected for this experiment. In this experiment the soil was enriched with application of 18 different combinations of organic and inorganic sources of Nitrogen. Urea was used as inorganic source of Nitrogen and various organic manures like cowdung, Neem cake, poultry manure, vermicompost, Phosphocompost, mustard cake was used as organic source of Nitrogen. Full of organic manure along with recommended dose of P & K and ½ dose of inorganic nitrogen (Urea) was applied as basal and rest ½ dose of Urea was applied after one month of transplanting. The phosphorus and potassium were used in the form of single Super Phosphate and Muriate of potash respectively. The experiment was started in the 1st week of October. Each plot area was 4.5m x 1.5m having 25 no. of plants with a spacing of 60 cm (Row to Row) x 45 cm (Plant to Plant) and replicated three times in the farmers field following Randomized Block Design. Observations were recorded on different parameters continued for two consecutive years and analyzed statistically as per Gomez and Gomez (1984) [2]. Standard biochemical method has been followed for estimation of Capsaicin & Ascorbic acid (Sadasivam and Manickam, 1996) [5] content of chilli.

Salient results of the different experimental approaches pursued in the present research programme and conclusions drawn on them are summarized here under.

Results and Discussion

The experiment with chilli var. Beladanga on integrated nutrient management was continued for two consecutive years and almost identical results were obtained in each year (Table 1).

Effect on vegetative growth

Plant height

The average plant height of chilli (63.86 cm) was found maximum under the treatment T11 (50% N from vermicompost + 50% N from Urea) followed by T12 (75% N from vermicompost + 25% N from Urea) over other treatments.

However, plants manured with 50% nitrogen as a source of vermicompost and another 50% N from urea increased 8.75% plant height over control. So, regarding the effect of different levels of applied organic manures along with inorganic nitrogen on growth of chilli var. Beladanga, it has been found that plant height increases with the increase in the level of inorganic nitrogen like urea (25 to 75%) and with reduced level of organic manure *viz*. cowdung manure (75 to 25%) and mustard cake (75 to 25%), whereas reverse effect was found with Neem cake, poultry manure, vermicompost and Phosphocompost. Normally plant height of this variety reached up to 58.72cm.

Number of branches per plant

The average number of branches per plant of chilli var. Beladanga was affected in such a way that, the number of branches (12.98) per plant was found maximum under the treatment T11 (50% N from vermicompost + 50% N from Urea) followed by T12 (75% N from vermicompost + 25% N from Urea) over other treatments. Whereas, number of branches per plant (9.72) was found very less when plant was grown with only P and K (Control) or Manured with 25% N (Cowdung manure) +75% N(Urea) (T1). These treatments produced 9.72 nos of branches per plant only, i.e. 25.11% less as compared to best combination as mentioned above, other combinations has a very little effect. In this aspect, Yadav and Vijayakumari (2004) [8] reported that plants treated with vermicompost containing highest chlorophyll in the chilli plant as compared to other organic manures used. So, plants manured with vermicompost along with fertilizer like urea (46% N) produced the best vegetative growth (8.0% increased plant height and 25% more number of branches per plant as compared to control) of chilli in this investigation.

Effect on flowering behaviour

Days required to first flowering

The different levels of organic manures and urea had significant influence on the number of days to first flower in the first year. Here, T1 (25% N and 75% N as a source from cowdung manure and urea respectively) bring the plants to induce advanced flowering by 3.5 days as compared to plant grow without application of N in control. Similarly, some other treatments also influenced the plants to earliness of flowering like T5 (50% N from neem cake + 50% N from urea), T6 (75% N from neem cake + 25%N from urea), T9 (75% N from poultry manure + 25%N from urea), T10(25% N from vermicompost + 75% N from urea), T13 (25% N from Phosphocompost + 75% N from urea), T16 (25% N from mustard cake + 75% N from urea), T17(50% N from mustard cake + 50% N from urea) and T18 (75%N from Mustard Cake + 25% N from urea), but difference is very negligible in comparison to control. On the other hand, flowering was delayed, when plants were treated with T2 (50% N from cowdung manure + 50% N from urea) and T14 (50% N from phosphocompost+50%N from urea) by 4 days over control. But Mustard cake as a source of N and its increasing dose (25 to 75%) to induced flower early by 2-3 days with all levels of nitrogen like urea (25, 50 and 75%). It has been also indicated that in this experiment, increase in inorganic nitrogen level (25, 50 and 75%) in the growing media flowering was delayed compared to all organic manures, except mustard cake. Maximum delay in flowering by 4 days were observed, when plants were Manured with 50% N from Phosphocompost and 50% N from Urea.

Number of flowers per plant

The average number of flowers per plant was maximum (260.20), when plants were Manured with T11 (50% N from vermicompost + 50% N from urea) followed by T12 in comparison to other treatments (120.60-250.20), whereas poor performance in this parameter was obtained (120.60) in T13 (25% N from Phosphocompost + 75% N from urea). It was observed that increased level of nitrogen from of urea (25, 50 and 75%) along with reducing doses of organic manures (75, 50 and 25%), like cowdung manure, Neem cake, poultry manure and vermicompost induced more number of flowers per plant, whereas, N as a source of Phosphocompost and mustard cake at higher level (75%) with low level of (25%) also showed positive response on flower production. All levels of nitrogen showed very pronounced effect on flower production (250.20-260.20) of chilli along with use of N in different doses received from vermicompost, but best combination was 50% N from both the sources (Vermicompost and Urea) and produces 42.19% more flowers as compared to control.

Effect on yield

Percentage of fruit setting

The integrated nutrient management significantly showed pronounce effect on percentage of fruit setting (%) of chilli (Table 1).

The average result of maximum percentage of fruit setting (67.80%) was recorded, when plants were manured with T18 (75%N from mustard cake +25% N from Urea), followed by T17and T16 at the percentage of 66.20 and 64.20 fruit setting respectively. Whereas, least performance was recorded under the treatment T15 (75% N from Phosphocompost and rest 25%N from urea), which influenced the plant having capacity of fruit setting only 45.20%. In normal condition (control), flowers set fruits with 52.60%.

However, chilli plant var. Beladanga increased percentage of fruit setting, when plants were fed with mustard cake and urea in different proportions (25 +75% of N, 50 +50% of N and 75 +25% of N). On the other hand application of nitrogen with Phosphocompost played a negative response in this aspect in all sets of combinations. On the other hand, cowdung manure, poultry manure, vermicompost and Phosphocompost as a source of N at reducing level with increasing level of inorganic nitrogen through urea increased fruit setting. Increasing nitrogen with neem cake and mustard cake (25, 50 and 75%N) reduced the percentage of fruit setting during investigation. So, where fruit dropping is a problem after flowering, it will be better to apply 50% nitrogen through mustard cake along with 50% nitrogen through Urea against this problem and near about 20.54% more fruit setting can be achieved as compared to normal practices (control).

Number of fruits per plant

The average performance of treatment like T11 (50% N from vermicompost + 50% N from urea) showed highest yield of individual plant (161 no. of fruits per plant) over other treatments (57-150 no. of fruits per plant). Both the treatments T10 & T12 showed very encouraging effect on fruit production per plant over other treatments. The number of fruits per plant is important to indicate yield potential. Here, cowdung manure, poultry manure and Phosphocompost when used as a source of N (25, 50, 75%) with urea in different combinations performed very poor in this aspect. Neem cake and Mustard Cake, when applied with urea this experiment showed better performance, whereas, recommended dose of N is used in chilli as shared with vermicompost and urea in all doses play a vital role in fruit production.

The best combination of urea and vermicompost at 50% (161 nos of fruits per plant) obtained 51.55% more fruits per plant, whereas 78 number fruits per plant was produced by untreated plant. In this context, Singh and Kumar (1999)[6] reported that highest fruit setting percentage and number of fruits per plant of chilli was found, when 90kgN/ha was applied during cultivation.

Fruit Weight (g)

The comparative study over the years showed that weight of fruit per plant was significantly different and best and worst performance was same as mentioned above. Weight of individual fruit was highest (7g) under treatment T11, and T10 (25% N from vermicompost + 75% N from urea) & T12 (75% N from vermicompost + 25% N from urea) were at par (6.80g) and the worst effect was found under control (4.0g) as well as plant treated with T9, (4.1g). Generally, each fruit weight of this variety was recorded 4 g at control i.e. without application of nitrogen, but when growing media was enriched with N as a source from organic manure like vermicompost and nitrogenous fertilizer as urea at 50% of both increased weight of fruit up to 42.85% more. Others organic manures along with urea also improved the fruit weight, but magnitude of improving is not so pronounced during a couple of years.

Fruit yield (g/ plant)

The average yield of individual plants as well yield per ha showed highly significant variation also. It is evident from the data that again the treatment T11 (50% N from vermicompost + 50% N from urea) significantly increased yield per plant and per hectare almost 2-5 times more (yield 1127 g/plant and 250.75 q/ha) in comparison to other treatments, except T10 (25% N from vermicompost + 75% N from urea) yield (990 g/plant and 227.50 q/ha) and T12 (75% N from vermicompost + 25% N from urea) yield (1006.4 g/plant and 245.50 q/ha). The lowest (yield 312 g/plant and 48 q/ha) performance was found under control. Various organic manures when mixed with growing media showed their significant role in yield per plant and per hectare of chilli like other parameters. The productivity of chilli in saline soil normally 312g/plant and 48 q/ha. When the soil was enriched with vermicompost and urea showed by 50%, very impressive encouraging result was found i.e. about 261.21% more yield in terms of per plant per hectare was obtained. Similarly, other combinations of vermicompost and urea as a source of nitrogen (25% +75% and 75 + 25%) also showed very beneficial effect in this aspect. Other organic manures like cow dung manure, poultry manure, Neem cake, Phosphocompost and mustard cake to improved yield to some extent, but not up to the mark of the above mention treatment in this experiment during investigation in a couple of years. Chopra *et al*. (2005) [1] reported the performance of chilli genotypes Punjab Gucherdar, Ludhiana long selsction, Punjab Lal, and CH-1 and CH-3. CH-3 was superior for yield and yield contributing traits, which recorded maximum fruit length (7.25 cm), fruit weight (5.0 g) and total yield (211.40 q).

According to Usha Rani *et al*. (2002) [7] the availability of phosphorus contents increase up to 200% in the soil during cultivation of chilli, when NPK +FYM @ 10 tons/ha is used in the soil followed by vermicompost @ 2.5 tonnes/ha with the same level of inorganic fertilizer. Biofertilizer application and integrated nutrient management with vermicomposting, green manuring also showed significant response in chillies and pepper (Nath *et al*., 2008) [4].

Effect on capsaicin and ascorbic acid content of fruits

Fruit samples were collected when the fruits started ripening and were analyzed to find out the capsaicin and ascorbic acid status of the fruits. The content of capsaicin and ascorbic acid in fruits as affected by different treatments showed (Table 2) wide range of variation (capsaicin content 60.76-114.2 mg/g dry biomass and ascorbic acid content 105.20-185.50 mg/100g of green edible chilli). The highest fruit content of capsaicin as well as ascorbic acid in fruit were recorded when plants were treated with recommended dose of nitrogen of 25% N as a source of neem cake + 75%N from urea (capsaicin content 114.2 mg/g dry biomass and ascorbic acid content 185.50 mg/100g of green edible chilli), whereas plants when applied with 50% N from cowdung manure + 50%N taken from urea as source of nitrogen (T5) recorded fruits having poor level of capsaicin (60.76 mg/g dry biomass), and plant treated with 75% N from Phosphocompost + 25% N from Urea (T9) having least level

of ascorbic acid(105.20 mg/100g). Capsaicin accumulation in fruit (99.56 mg/g dry biomass) and ascorbic acid (175.50 mg/100g of green edible chilli) was noted in this treatment T11 (50% N sharing from vermicompost + total N of 50% from urea) that brought about maximum improvement in yield.

Regarding analysis of fruit, there is a tremendous effect on capsaicin content and ascorbic acid in the fruits of chilli var. Beladanga. Normally, the fruit content of capsaicin in fruit was found 82.60 mg/g dry biomass and ascorbic acid 120.0 mg/100g of green edible chilli. Low level of N (25%) from different organic manures with high level of N (75%) from inorganic source (urea) to markedly improved the capsaicin content in the fruit of chilli. The highest capsaicin (144.2 mg/g dry biomass) and ascorbic acid content (185.50 mg/100g of green edible chilli) in fruits was obtained when growing media is enriched with 25% N taken from Neem cake + 75% N from urea.

However, vermicompost mixed in the soil acted to improve soil aeration and simultaneously reduced soil compactness. Although basically vermicompost is low nutrient (NPK) content than inorganic, but due to its porous nature and some other properties promoted root growth and consequently improved plant growth. Moreover, it supplies good amount of calcium and phosphorus to the plant. Thus, nitrogen mixed with soil brought about significant improvement in vegetative growth like plant height, number of branches per plant. Cowdung manure and Mustard cake also showed their beneficial effect on vegetative growth of chilli when used along with nitrogen. So, in the saline soil for chilli cultivation, vermicompost and urea when used as a source of nitrogen of recommended dose at 50% ratio play an important role in production. But, regarding the quality aspect, Neem cake acted as vital role for improvement of capsaicin and ascorbic acid content in the fruit.

Benefit cost ratio

Comparative details of the Cost of cultivation for different treatments

In the present experiment of integrated nutrient management through eighteen different treatments of organic fertilizers and inorganic fertilizers applied accordingly and their synergistic effects on yield attributes and overall performances with respect to economics of cultivation, Beladanga variety of chilli in Saline belt of West Bengal showed that the highest gross return as well as profit was found in treatment T11 (50% N from VC + 50% N from Urea) of Rs. 313437.5/- per hectare followed by the treatment T12 (75% N from VC + 25% N from Urea) of Rs. 306875.0/- per hectare and T10 (25% N from VC + 75% N from Urea) of Rs. 284375.0/- per hectare respectively over control. It is emerged that the vermicompost has most significant effect on yield of Beladanga variety of chilli. The said variety also performed better with application of Neem cake followed by mustard cake.

Benefit Cost ratio for different treatments on Beladanga variety of chilli in Saline belt of West Bengal

From the present investigation details breakup of the cost components for each treatments on Beladanga variety of chilli along with their operational cost and farm harvest price have been collected. It could be determined that cultivating of one hectare of Beladanga with the vermicompost, mustard cake and Neem cake have significant effect in respect to yield over control, whereas, three treatments of vermicompost showed best effects over all treatments. We can get with treatments of vermicompost, mustard cake and Neem cake, a minimum highest return of Rs. 5.52/-, Rs. 3.60/-, and Rs.3.48/-, respectively by spending one rupee for cultivation. It is concluded from the above experiment that cultivation of Beladanga variety in respect to treatment of vermicompost with three different combination and its effects is found to be most remunerative which is closely followed by mustard cake and Neem cake in the saline areas of West Bengal. However, poultry manure, Phosphocompost and cowdung Manure treatment may be economically viable over control in Saline belt of West Bengal subject to specific treatments on yield and farm harvest price prevailing at that region and time. The economic analysis indicated that the highest gross monetary return (Rs. 1, 27, 328/ha), net monetary return (Rs. 1, 00, 133/ha) and benefit cost ratio (4.68) was recorded in the treatment T1 (Medhe *et al*., 2010) [3].

Table 1: Mean effect of integrated nutrient management on vegetative growth, flowering and yield of chilli var. Beladanga in saline belt of West Bengal

Treatments	Plant height (cm)	No. of branches per plant	Days required to first flowering	No. of flowers per plant	Percentage of fruit setting (%)	No. of fruits per plant	Fruit Weight (g)	Fruit yield (g/plant)	Fruit yield (q/ha)
T_1: 25% N(CM) + 75% N(IN)	61.78	9.72	44.50	180.60	55.20	99.00	4.60	455.40	113.85
T_2: 50% N(CM) + 50% N(IN)	61.77	10.23	50.00	162.20	52.60	85.00	4.80	408.00	102.00
T_3: 75% N(CM) +25% N(IN)	60.11	9.97	47.00	160.00	49.80	80.00	4.20	336.00	84.00
T_4: 25% N(NC) + 75%N(IN)	61.19	9.92	47.00	200.00	58.20	116.0	5.20	603.20	150.80
T_5: 50% N(NC)+ 50%N(IN)	61.77	10.20	44.00	205.60	59.20	120.0	5.60	672.00	168.00
T_6: 75% N(NC) + 25%N(IN)	62.87	10.04	45.50	198.60	60.00	119.0	5.10	606.90	151.72
T_7: 25% N(PM) + 75%N(IN)	59.32	10.28	47.50	182.60	51.00	93.00	4.20	390.60	97.65
T_8: 50% N(PM) + 50%N(IN)	60.86	12.75	46.50	178.60	52.60	93.00	4.40	409.20	102.30
T_9: 75% N(PM) + 25%N(IN)	61.73	11.50	44.50	172.20	46.20	79.00	4.10	323.90	80.97
T_{10}: 25%N(VC) + 75% N(IN)	61.43	11.56	44.00	250.20	60.50	150.0	6.80	990.00	227.50
T_{11}: 50% N(VC) + 50% N(IN)	63.86	12.98	46.00	260.20	62.60	161.0	7.00	1127.0	250.75
T_{12}:75% N(VC) + 25% N(IN)	62.89	12.40	46.50	256.40	58.20	148.0	6.80	1006.4	245.50
T_{13}: 25% N(PC) + 75%N(IN)	59.87	10.65	43.50	120.60	48.60	57.00	5.20	296.40	74.10
T_{14}: 50% N(PC) + 50%N(IN)	59.34	11.10	50.00	130.20	46.20	59.00	5.80	342.20	85.55
T_{15}: 75% N(PC) + 25%N(IN)	60.85	10.78	46.00	142.20	45.20	64.00	6.00	384.00	96.00
T_{16}: 25% N(MC) + 75% N(IN)	61.02	11.08	44.50	166.80	64.20	106.0	5.60	593.60	148.25
T_{17}: 50% N(MC) + 50% N(IN)	62.00	11.35	45.50	176.80	66.20	116.0	5.20	603.20	150.75
T_{18}: 75% N(MC) + 25% N(IN)	59.03	11.16	44.50	172.20	67.80	115.0	5.40	621.00	155.25
T_{19}: Control	58.72	9.72	46.00	150.40	52.60	78.00	4.00	312.00	48.00

S.E.m	0.350	0.185	0.702	1.411	1.319	2.002	0.158	8.484	3.468
CD at 5%	1.040	0.550	2.085	4.190	3.920	5.945	0.470	25.2	10.30

CM: Cowdung manure, NM: Neem cake, PM: Poultry manure, VC: Vermicompost, PC: Phosphocompost, MC: Mustard Cake, IN: Inorganic Nitrogen (Urea),

Table 2: Effect of integrated nutrient management on capsaicin and ascorbic acid content of fruits of Chilli var. Beladanga

Treatments	Capsaicin (mg/g dry biomass)	Ascorbic acid(mg/100g)
T_1: 25% N(CM) +75% N(IN)	60.76	160.00
T_2: 50% N(CM) + 50% N(IN)	77.96	162.00
T_3: 75% N(CM) +25% N(IN)	106.60	165.00
T_4: 25% N(NC) + 75%N(IN)	114.20	185.50
T_5: 50% N(NC)+ 50%N(IN)	107.60	180.50
T_6: 75% N(NC) + 25%N(IN)	79.20	178.60
T_7: 25% N(PM) + 75%N(IN)	93.80	122.80
T_8: 50% N(PM) + 50%N(IN)	80.50	116.40
T_9: 75% N(PM) + 25%N(IN)	76.80	114.60
T_{10}: 25%N(VC)+75% N(IN)	113.60	175.60
T_{11}: 50% N(VC)+ 50% N(IN)	99.56	175.50
T_{12}:75% N(VC +25% N(IN)	90.90	177.60
T_{13}: 25% N(PC) + 75%N(IN)	77.30	178.60
T_{14}: 50% N(PC) + 50%N(IN)	72.43	110.60
T_{15}: 75% N(PC) + 25%N(IN)	72.00	105.20
T_{16}: 25% N(MC)+75% N(IN)	99.18	178.00
T_{17}: 50% N(MC)+50% N(IN)	98.18	180.80
T_{18}: 75% N(MC)+25% N(IN)	85.45	180.40
T_{19}: Control	82.60	120.60
S.E.M	1.42	1.16
CD at 5%	4.42	3.11

CM: Cowdung manure, NM: Neem cake, PM: Poultry manure, VC: Vermicompost, PC: Phosphocompost, MC: Mustard Cake, IN: Inorganic Nitrogen (Urea)

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