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Effect of integrated nutrient management on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.)

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Abstract
The experiment was conducted to study the effect of integrated nutrient management on growth and yield of cabbage at research farm, Department of Horticulture, Udai Pratap Autonomous College, Varanasi (U.P.) during *Rabi* season of 2016-17. The experiment was laid out in a randomized block design (RBD) with nine treatments replicated thrice. The treatment comprised of different levels of NPK, farmyard manure (FYM), vermicompost, phosphorus solubilizing *mycorrhiza and Azospirillum*. The results revealed that the application of different levels of fertilizers, in combination with organic manures and bio-fertilizers significantly increased the growth and yield of cabbage. The number of non-wrapped leaves (14.46), weight of non-wrapped leaves plant^{-1} (644.53 g), days taken to maturity (75.53), head size index (351.53 cm^2), head weight (1207.86 g) and yield per hectare (447.69 q ha^{-1}) were recorded with the combined application of half dose of NPK+ vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1}.from the study it was concluded that the application of vermicompost or FYM + *Azospirillum*+ phosphorus solubilizing *mycorrhiza along with NPK was recommended for higher cabbage crop yield.*

Keywords: Bio-fertilizer, cabbage, farmyard manure, organic manures, phosphorus solubilizing *mycorrhiza*, vermicompost

Introduction
The cabbage (*Brassica oleracea* var. *Capitata*) is a member of Cole crop belongs to the family crucifareae and originated from the Mediterranean region. Cabbage is grown throughout the world. It is important Cole crop mainly grown in Uttar Pradesh, West Bengal, Gujarat, Orissa, Bihar, Assam, Maharashtra and Karnataka. The area under cabbage in India about 3.94 Mha with annual production of 88.06 Mt and productivity of 22.14 t ha^{-1} (NHB 2015-16). From the nutritive point of view cabbage is an excellent source of Vitamin A (2000 I.U./100 g) and Vitamin C (124 mg/100 g) and also has anti-carcinogenic properties (Birt, 1988) [5]. It contains 91.9 % moisture, 1.8 % protein, 0.1% fat, 0.6 % minerals. It is also rich in thiamine and riboflavin. The productivity of cabbage is influenced by several factors such as soil fertility, varieties and climatic conditions. The conjunctive use of organic and inorganic sources will improve soil health and helps in maximizing production as it involves utilization of local resources and hence, turned to be a rational, realistic and economically viable way to supply nutrients to the crop. The basic concept of integrated nutrient management (INM) is to improve soil health and maintain soil fertility status. It ensures regular nutrient supply to the optimum level for sustaining the desired crop productivity. The appropriate combination of inorganic and organic nutrient sources according to the soil condition, climate, ecological, and socio-economic conditions leads to better crop growth and yield. Chemical fertilizers supply only one or two nutrient elements to the soil and prolong use of chemical fertilizers deteriorate soil quality also. The integrated use of chemical fertilizers, FYM, biofertilizers and other organics hold great promise for securing high level of crop productivity and also to protect soil health from deterioration and pollution hazards. FYM supply organic matter, improve soil physical, chemical and biological properties. It act as a storehouse of the nutrients but its alone application suffers from the drawback of bulky demand and low nutrient status. To supply crop nutrients only through organic manure we need huge amount of manures which is neither possible nor economically viable.

Biofertilizers are microbial inoculants that consist of living or latent cells of different strains of microorganisms in one or another way rather nutrients available to plant from sources which these plants cannot use themselves. The application of bio-fertilizers helps in improving the number of biological activities of desired microorganisms in soil and helps to improve plant growth and yield. Certain microbes has the capacity to fix atmospheric N, some other microbes increase availability of some nutrients such as P, S, Mn and Zn. They also stimulate plant growth by producing bioactive compounds in the soil. Further, bio-fertilizers are the non-bulky and cheap sources of nutrients and may prove cost-effective and eco-friendly supplementation in vegetable farming. In this concern *Azospirillum and* phosphorus solubilizing *mycorrhiza* are two important biofertilizers who has the capacity to fix nitrogen symbiotically and solubilize phosphorus respectively

Chemical fertilizers and organic manures play a vital role in vegetable production. The Nutrient supply system is considered one of the basic factors in crop production. It has been established beyond doubt that there is a positive correlation between fertilizer use and crop productivity. Farmers are using excessive chemical fertilizers leads to decline in organic carbon. The excessive use of chemical fertilizers spoils the structure and texture of the soil. Therefore, the use of chemical fertilizer alone may not keep pace with time in the maintenance of soil health for sustaining productivity.

Hence, the application of inorganic plant nutrients along with organic sources leads to better soil and more crop yield. High yield of cabbage cannot be realized with the use of organic manure, fertilizers and bio-fertilizers alone. The use of organic manures in conjugation with fertilizers not only enhances the efficiency of fertilizers but also partly supply nutrients for longer period of time to maintain nutrient. The use of different sources of nutrients in an integrated manner helps to produce sustainable yield with good quality. In the present study, the efforts were made to boost crop productivity by using fertilizers, FYM, vermicompost and phosphorus solubilizing *mychorriza* in integrated manner.

Materials and Method

Experimental site and climatic condition

The field experiment was carried out at research farm of Department of Horticulture, Udai Pratap Autonomous College, Varanasi (U.P.) during *rabi* season of 2016-17. Geographically, Varanasi is located at 25.35^0 N latitude and 82.97^0 E longitudes on an elevation of about 128.93 meter sea level in the Gangatic alluvial plain of Eastern, Uttar Pradesh. The experimental site falls under a humid-sub tropical climate with maximum summer temperature ranging from 29.6 to 40.3 ^{0}C and minimum ranging from 9.2 to 23.2 ^{0}C in winter. Varanasi region received mean annual precipitation of about 1000 mm. Maximum rainfall in this region was received from mid-June to end of September. However, occasional showers are also very cold whereas summer months are extremely hot and western hot winds locally known as *loo* start from April and continued till the onset of monsoon in the month of June.

Experimental design and treatment details

The experiment was carried out in Randomized Block Design (RBD). The experiment was consisted of nine treatments replicated thrice. Details of treatments presented in table 1.

Table 1: Different treatments used in the experiment

Legends	Treatments
T_1	Recommended dose of NPK ha^{-1} (150 kg: 125 kg: 100 kg)
T_2	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}
T_3	Half dose of NPK ha^{-1} + FYM @15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}
T_4	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}
T_5	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}
T_6	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}
T_7	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}
T_8	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Phosphorous Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}
T_9	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}

Seed treatment and Nursery preparation

Cabbage variety Shri Ganesh gol was taken for the experiment and the seeds were treated with fungicide (Thiram @ 2.5 g kg^{-1}) before sowing in nursery bed. Treated seed were sown in a well prepared raised bed by opening the miniature furrow at 5 cm distance. Seeds are sown in nursery bed during 1st week of October, 2016. After sowing the seeds, a light film of well rotten FYM was spread over them. After covering the seeds light irrigation was given with the help of sprinkler with rose cane and beds were covered with paddy mulch. Paddy mulch was removed from the beds, just after seedling emergence and after this sufficient moisture was maintained till transplanting in main field.

Main field preparation and transplanting of seedlings

The field was harrowed twice followed by planking and leveling. The layout was prepared on field and the respective amount of FYM and vermicompost was applied before fifteen days and fields were leveled using spade. The powder of PS*M* was mixed with some light fine soil and applied just before transplanting as per treatments. *Azospirillum* was used to dipping seedling roots for 30 min just before transplanting. The transplanting was done using vigorous five to six weeks old seedlings during second week of November, 2016 with a spacing of 60 x 45 cm.

Full dose of Phosphorus, Potassium and 1/3rd dose of Nitrogen were applied as basal and remaining 2/3rd nitrogen was applied in two split doses *i.e.* 30 and 45 DAT respectively.

The statistical analysis of data was done using analysis of variance technique for randomized block design of field experimentation suggested by Panse and Sukhatme (1989) [12]. The difference between the treatment means were compared by critical difference of 5% (p=0.05) level of significance.

Observations Recorded

The crop was harvested at 90 days after transplanting. The vegetative parameters of growth *viz.* Plant height, stalk length, stalk diameter, number of non-wrapped leaves plant^{-1}, weight of non-wrapped leaves (g plant^{-1}), days taken to maturity and

the yield parameters *viz.* spread of the plant, head size index (cm^2), head diameter (cm), yield per plant (g), yield per hectare (q ha^{-1}).

Results and Discussion

The results obtained from the experiment are explained in the light of facts and figure under the following heads.

Growth Attributes

Plant height

The plant height of various treatments was influenced significantly. The maximum plant height (24.93 cm) was recorded with the application of half dose of NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} along with phosphorus solubilizing *mycorrhiza* (PSM) @ 5 kg ha^{-1} which was *at par* with the half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} (24.40 cm). The minimum plant height (20.13 cm) was recorded in treatment consisting of half dose of NPK + FYM @ 15 t ha^{-1}. The more availability of nutrient leads to more uptakes of nutrients in the plant which is essential for the proper growth and development of plants. Nitrogen is the part of chlorophyll pigment which helps in photosynthesis. More photosynthesis leads to more plant growth in terms of more plant height. The same results were also reported by Kanwar *et al.* (2002) [8], Singh and Khare (1998) [15] and Singh *et al.* (2009) [14] in cole crops.

Stalk length and diameter

The stalk length and diameter was also significantly improved by various INM levels. The maximum stalk length (8.73 cm) and diameter (4.40 cm) was recorded with application of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} followed by half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1}. The minimum stalk length (6.13 cm) and diameter (2.86 cm) was recorded with the treatment consisting half dose of NPK + FYM @ 15 t ha^{-1}. Regular supply of nutrients helps to regulate various biochemical processes in the plant system. The numerous compounds which participate in the dry matter production and portioning contain mineral elements. The sufficiency of elements helps in photosynthesis and the more photosynthates partitioning helps in more growth which leads to more stalk length and diameter. A similar result was also reported by Singh *et al.* (2009) [14].

Number and fresh weight of non-wrapped leaves

The maximum number of non-wrapper leaves (14.46) were recorded with the application of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} which was *at par* with half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} `(14.20) and half dose of NPK + vermicompost @ 2.5 t + PSM @ 5 kg ha^{-1} (13.80) while the minimum number of non-wrapper leaves (10.43) were recorded with treatment half dose of NPK + FYM @ 15 t ha^{-1}. The fresh weight of non-wrapped leaves was recorded just after harvesting. The maximum weight of leaves per plant (644.53 g) was recorded by the application of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} which was significantly higher than other treatments and *at par* with half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} (640.50 g). However, lowest value (507.86 g) was recorded by the application of half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}. Nitrogen is the primary structural component of chlorophyll pigments which helps in photosynthesis and accumulation of more dry matter which helps in more production of non-wrapped leaves. Though they are non-economical but contribute significantly to the process of photosynthesis. The similar findings were also reported by Bhagavantagoudra and Rokhade (2001) [4], Singh *et al*. (2009) [14] and Choudhary and Choudhary (2005) [6].

Days to maturity

The total duration for maturity in days was recorded from the date of transplanting. It was found that the more duration (75.53 days was found by the application of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} and late maturity) and early maturity (61.46 days) found by the application of half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}. The deficiency of one or more nutrients in the plant leads to the forced maturity as a result less plant growth and development occurs. While sufficiency of nutrients leads to more crop duration and more crop growth. The findings are in corroboration with the finding of Agrawal and Agrawal (2003) [2].

Spread of plant

The maximum spread of plants was observed with the application of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} (52.30 cm) which was *at par* with half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} (51.73 cm). The minimum plant spread (42.46 cm) was found in treatment consisting of half dose of NPK + FYM @ 15 t ha^{-1}. More growth of the plant is due to the proper supply of the nutrients resulted in more spread of the plant. The findings are is in accordance with Singh (2009) [14].

Yield and yield attributes

All the yield and yield attributes *viz.* diameter of head, head size index, head yield and total yield were significantly influenced by the application of different INM treatments. The data pertaining to the different yield and yield attributes is present in table 3.

Head diameter

The maximum head diameter was recorded (24.33 cm) with application of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} while the lowest value recorded with half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}. The same finding has been reported by Kumar and Rawat (2002) [10].

Head size index

Maximum head size (351.53 cm^2) was recorded with half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} which was *at par* with half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} while the lowest value (263.40 cm^2) was observed with half dose of NPK + FYM @ 15 t ha^{-1}. The similar value was recorded by Sharma (2002) [13] in cabbage.

Head Yield (g)

The maximum head yield $plant^{-1}$ (1207.86 g) was recorded with the treatment consisting of half dose of NPK + vermicompost @ 2.5 t + *Azospirillum* @ 5 kg + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} which was *at par* with

half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} (1201.86 g) and half dose of NPK + vermicompost @ 2.5 t + PSM @ 5 kg ha^{-1} (1175.20 g) while the minimum weight (933.86 g) was recorded with the application of half dose of NPK + FYM @ 15 t ha^{-1}. The similar result was also reported by Khan *et al*. (2010) [9] in cauliflower.

Yield

The maximum yield of cabbage (447.69 q ha^{-1}) was obtained with the half dose of NPK + vermicompost @ 2.5 t + phosphorus solubilizing *mycorrhiza* @ 5 kg ha^{-1} however this was *at par* with the treatment consisting of half dose of NPK + FYM @ 15 t + PSM @ 5 kg + *Azospirillum* @ 5 kg ha^{-1} (445.47 q ha^{-1}) and half dose of NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} + PSM @ 5 kg ha^{-1} (435.59 q ha^{-1}). The minimum yield (346.21 q ha^{-1}) was recorded with half dose of NPK + FYM @ 15 t ha^{-1}. Yield is the resultant of the cumulative effect of yield attributes. Different yield attributes like plant yield^{-1}, head size, head diameter significantly influenced by the availability of nutrients. Nitrogen, phosphorus and potassium are the functional and structural supporting elements that perform direct or indirect role in plant metabolism, translocation of photosynthates and energy conversion. They are part of various enzymes and hormones and regulate various enzymatic reactions. The inadequate supply of one or more nutrients leads to improper growth and development of the plant which ultimately influences yield and yield attributes. The treatment consisting of combined application of organic and inorganic nutrient sources has the capacity to provide adequate amount of macro nutrient along with some micro nutrients. The vermicompost contains some enzymes and hormones like auxin which stimulate more plant growth. vermicompost and manures both act as a chelating agent that hold nutrients for a longer period of time and ensures their availability throughout the crop growth period. It also has the capacity to hold more water as compared to normal soil. They decrease the bulk density of the soil which promotes more root growth and more uptake of nutrients. The present finding is in accordance with Ghuge *et al*. (2007) [7] in Cabbage and Kanwar *et al*. (2002) [8] in cauliflower.

Table 2: Effect of integrated nutrient management on Growth attributes of cabbage

Treatments	Height of Plant (cm)	Number of non-wrapped leaves per plant	Fresh weight of non-wrapped leaves (g/plant)	Length of stalk (cm)	Diameter of stalk (cm)	Days taken to maturity
T_1 - Recommended dose of NPK ha^{-1} (150 kg : 125 kg : 100 kg)	21.73	13.13	547.53	6.86	3.40	62.46
T_2 - 50% NPK ha^{-1} + FYM @ 15 t ha^{-1}	20.13	10.43	507.86	6.13	2.86	61.46
T_3 - 50% NPK ha^{-1} + FYM @ 15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	21.93	13.40	570.53	7.13	3.53	64.60
T_4 - 50% NPK ha^{-1} + FYM @ 15 t ha^{-1} + PS*M* @ 5 kg ha^{-1}	22.53	13.53	593.86	7.26	3.80	65.60
T_5 - 50% NPK ha^{-1} + FYM @ 15 t ha^{-1} + PS*M* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	24.40	14.20	640.50	8.13	4.06	75.26
T_6 - 50% NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}	21.76	13.26	557.53	7.06	3.40	63.03
T_7 - 50% NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	22.26	13.40	582.53	7.16	3.73	65.23
T_8 -50% NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + PS*M* @ 5 kg ha^{-1}	22.53	13.80	610.53	7.46	3.93	70.96
T_9 -50% NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5kg ha^{-1} + PS*M* @ 5 kg ha^{-1}	24.93	14.46	644.53	8.73	4.40	75.53
S.Em.±	0.326	0.245	7.994	0.131	0.046	0.915
C.D. at 5%	0.984	0.741	24.171	0.395	0.138	2.768

Table 3: Effect of integrated nutrient management on yield and yield attributes of cabbage

Treatments	Spread of plant (cm)	Diameter of head (cm)	Head Size Index (cm^2)	Head yield (g)	Yield (q ha^{-1})
T_1 -Recommended dose of NPK ha^{-1} (150 kg : 125 kg: 100 kg)	45.53	17.60	285.53	996.00	369.42
T_2 -Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}	42.46	16.53	263.40	933.86	346.21
T_3 -Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	46.46	18.20	291.20	1030.53	382.01
T_4 -Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}	47.20	19.86	314.00	1095.20	405.96
T_5 -Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	51.73	23.20	351.06	1201.86	445.47
T_6 -Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}	46.33	18.13	290.86	1021.20	378.55
T_7 -Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	47.00	19.53	292.53	1063.86	394.36
T_8 -Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} +Phosphorous Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}	47.20	20.80	321.60	1175.20	435.59
T_9 -Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}	52.53	24.33	351.53	1207.86	447.69
S.Em.±	0.648	0.313	5.477	11.459	6.418
C.D. at 5%	1.961	0.947	16.563	34.650	19.408

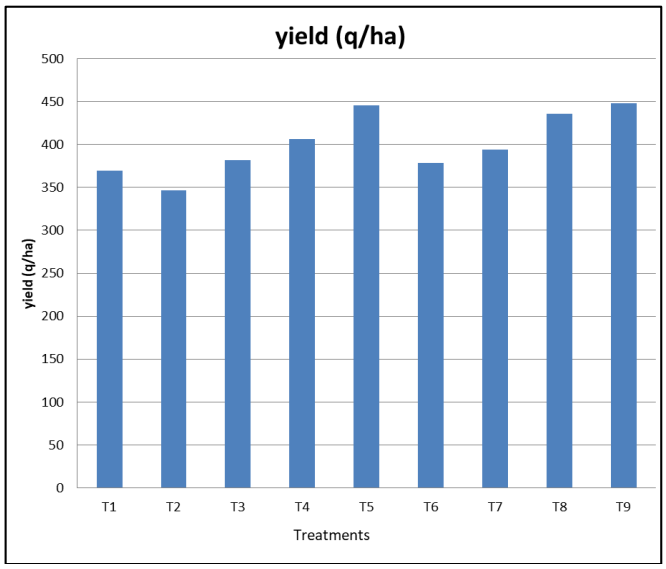

Fig 1: Effect of INM on cabbage yield

Conclusion

In the study, it was found that integrated nutrient management (INM) has the capacity to produce more yield without deteriorating the soil quality and environmental health. INM promises more economic return with a better quality of produce. Thus from the study, it can be concluded that the application of Vermicompost @ 2.5 t or FYM @ 15 t + *Azospirillum* @ 5kg + PSM @ 5 kg ha^{-1} along with half dose of NPK (75:62.5:50 kg ha^{-1}) can be recommended for higher yield return in cabbage under Gangatic alluvial plain of Eastern, Uttar Pradesh.

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References

1. Acharya D, Mondal SS. Effect of integrated nutrient management on growth, productivity and quality of cabbage. Indian journal of agronomy. 2010; 55(1):1-5.
2. Agrawal, Agrawal N. Influences of nitrogen on growth and head characters of cabbage in Chandigarh region. Progressive horticulture. 2003; 35(2):237-238.
3. Anonymous. National horticulture board Data Base, 2016.
4. Bhagavantagoudra KH, Rokhade AK. Effect of *azospirillum* and nitrogen on growth and yield of cabbage. Karnataka journal agricultural sciences. 2001; 14(3):858-861.
5. Birt FD. Anticarcinogenic factors in cruciferous vegetables. In, Quebdeaux, B. and Bliss, F.A.(eds.). Horticulture and human health, 1988, 160.
6. Chaudhary RK, Chaudhary DN. Effect of different levels of nitrogen and phosphorus on growth, yield and quality of hybrid cabbage. Haryana journal of horticulture science. 2005; 34(1, 2):145-146.
7. Ghuge TD, Gore AK, Jadhav SB. Effect of organic and inorganic nutrient sources on growth, yield and quality of cabbage (*Brassica oleracea* var. *capitata*). Journal of soils and crops. 2007; 17(1):89-92.
8. Kanwar K, Paliyal SS, Nandal TR. Integtrated nutrient management in cauliflower (Pusa Snowball K-1). Research on crops. 2002; 3(3):579-583.
9. Khan N, Srivastava JP, Singh SK. Effect of biofertilizers on production potential of cauliflower (*Brassica oleracea* var. *botrytis* L.) Annals of horticulture. 2010; 2(1):122-123.
10. Kumar M, Rawat TS. Effect of nitrogen and spacing on quality and yield of cabbage (*Brassica oleracea* var. *capitata* L.). Agriculture science digest. 2002; 22(2):90-92.
11. Kumaran SS, Natrajan S, Thamburaj S. Effect of organic and inorganic fertilizers on growth, yield and quality of tamato. South Indian horticulture. 1998; 46(3, 6):203-205.
12. Panse VG, Sukhatme PV. Statical Method for Agriculture of Workers. 5th Ed. ICAR, New Delhi, 1989.
13. Sharma KC. Effect of *Azospirillum*, *Azotobactor* and nitrogen on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.). Indian journal of agriculture. 2002; 72(9):555-557.
14. Singh A, Singh T, Singh BN. Influence of integrated nutrient management on growth, yield and economics of cauliflower (*Brassica oleracea* var. *botrytis* L.). Vegetable science. 2009; 36(1):340-343.
15. Singh K, Khare RK. Effect of azospirillum, azotobacter, nitrogen on growth and yield of cabbage under rainfed condition. Silver jubilee national symposium, ISVS Abst. 1998, 109.