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Effect of plant growth regulators on growth and yield of Cabbage (*Brassica oleraceae* var. *capitata*)

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Abstract
To study the response of foliar application of PGRs *viz*; GA_3 and NAA with their different concentration. The Study was carried out in Randomization block design replicated trice and the treatments comprised of four levels of each PGRs namely GA_3 (30,60,90 and 120 ppm) and NAA (25,50,75 and 100 ppm) along with control. Observations were recorded at 40 and 60 days after transplanting. The results revealed that all must all the parameters different significantly expect plant height at 40 DAT and stalk length at 40 & 60 DAT. GA_3 – 120 ppm increase the plant spread(2073cm^2 60 DAT) head diameter (19 cm), fresh weight (1399.7 g), dry weight(103.7 g), yield /plots (30.5 kg) yield/hectare (407.0 qha^{-1}). It is also mentioned that highest B:C ratio of 1:2.83 was recorded for NAA 100 ppm which was closely followed by treatment GA_3 120 ppm (2.81).

Keywords: Cabbage, GA_3, NAA, yield, maturity, fresh weight

Introduction
The edible portion of cabbage plant is formed by the fleshy leaves overlapping one another. It is used alone or mixed with potatoes for vegetable purpose, more in raw than in processed form. It has been reported that 100 g of green edible portion of cabbage contain 92% water, 18 mg Sodium, 170 mg Potassium, 1.28 g Protien, 5.8 g Carbohydrate, 4% Calcium, 2%mg Iron. Cabbage is cultivated on (2473271 ha.) area all over the world with (71259199 Metric tonnes) production with (28.81mt/ha) average yield (FAO STAT 2016). China ranks first in area and production followed by India. (FAO Stat 2016). In India, cabbage is grown in an area of 395 thousand hectares and production of 8807 Metric tonnes with productivity of 22.29 Metric tonnes ha^{-1} (NHB 2016-17a). Major cabbage growing states in India are Odisha, West Bengal, Karnataka, Maharashtra, Gujarat, and Punjab. In Madhya Pradesh 614.44 Metric tonnes of cabbage is produced annually from 29 thousand hectare, with productivity of 21.18 Metric tonnes ha^{-1} (NHB 2016-17b).
Plant growth regulators are defined as an organic chemical other than nutrients which in small amount promote, inhibit or other-wise modify the plant physiological processes. It increases the yield and improve the quality by alerting the behaviour of plant and number of physiological processes in plant systems. They help in synthesis of metabolites and translocation of nutrients and assimilation of these into different plant parts which ultimately resulting higher yields and improve the quality. Chhonkar and Jha (1963) observed that NAA at lower concentration was found effective in promoting early recovery and less mortality of seedling. Quick and percent recovery, early head formation and quality of cabbage due to GA treatment have been reported by Chhonkar and Singh (1964). Therefore the present study was carried out looking to the above finding of different works on PGRs.

Material and Method
The present field experiment was carried out during winter (*Rabi*) season of 2018-19 at Department of Horticulture Research Farm, College of Agriculture, Tikamgarh (M.P.). Tikamgarh district falls under 'Bundelkhand Zone (Agro-climatic Zone-VIII)". It has sub-tropical climate characterized by hot - dry summers and cool - dry winter. Tikamgarh is medium black soil having loamy texture. The experiment was laid out in Randomized Block Design with nine treatments replicated thrice. The experimental material for this study comprised of different growth regulators namely GA_3 and NAA and Selection-51variety of Cabbage.
The two plant growth regulators *viz*. GA_3 @ 30, 60, 90, 120 ppm and NAA @ 25, 50, 75, 100 ppm were tried and compared with control. The spraying was done at 40 and 60 Days after

transplanting (DAT), all the standard packages and practices were followed. The plant transplanted in row to row 60 cm and plant to plant 45 cm apart by hand in 3 X 2.5m plots farmyard manures 12 t/ha should be incorporated in the soil at the time of initial ploughing and full dose inorganic fertilizer of RDF (120:50:50 Kg NPK ha^{-1}). Entire full dose of P and K along with ⅓ part of N should be applied as basal dose. Reaming N may be applied one month after sowing. The observations were recorded on growth and yield parameter of cabbage. The growth parameters *viz*., plant height (cm), plant spread (cm^2), number of non wrapping leaves per plant, stalk length (cm), head diameter(cm), days taken for initiation of head after transplanting and days taken for complete maturity of head. The yield and yield attributes *viz.*, Fresh weight of head (g), dry weight of head (g), yield per plot (kg) and yield per hectare (q) economics of crop cultivation were recorded after harvest. Statistical analysis of the data was done by using Analysis of Variance (ANOVA)technique.

Result and discussion

Results,presented in table-1 & Table-2 revealed that all most all thestudied traits were affected by the treatments and there was completely significant difference between control and foliar application (Table-1) & (Table-2).The result of the present experiment indicates that foliarapplication of $GA_3$and NAA significantly increased the growth and yield parameters of Cabbage. At 40 DAT highest plant height was recorded application of GA_3 30 ppm (15.7 cm) where as minimum plant height (13.9 cm) was recorded in treatment (T9) control and at 60 DAT application of GA_3 30 ppm significantly maximum plant height of 19.3 cmand minimum plant height was recorded in control T9 (16.7 cm).Among different plant growth regulators, GA_3 recorded maximum plant height followed by NAA was observed. Similar results were reported by Pandita *et al*. (1980), Vijay and Ray (2000), Yadav *et al*. (2000), Patil *et al.* (2003), Dhengle and Bhosale (2007), Jadon *et al*. (2009), Lendve *et al*. (2010) [3] and Sitapara *et al.* (2011) [11]. Significantly maximum plant spread at 40 and 60 DAT(1718 $cm^2$and 2073 cm^2) was recorded with treatment $GA_3$120 ppm and minimum plant spread was recorded in control T9 (1443.3 and 1977.7 cm^2).GA_3 at higher concentration leads to leaf expansion which helps to spread plants. The similar work was presented by Dhengle and Bhosale (2007), Dhengle and Bhosale (2008), Lendve *et al.* (2010) [3]. Significantly maximum number of non wrapping leaves 40 DAT was recorded with treatment GA_3 @ 90 ppm (13.1), at 60 DAT maximum number of non wrapping leaves was recorded GA_3 @ 90 ppm (13.7) where as minimum number of non wrapping leaves was recorded in (T9) control (11.2). The increase in number of non-wrapping leaves per plant due to the activity of gibberellic acid at the apical meristem resulting in more nucleoprotein synthesis was responsible for increasing the leaf initiation and expansion. Sam result were noted by Simona *et al*. (1960), Islam *et al.* (2017) [1], Meena *et al.* (2018) [5], Increase in stalk length is a indication of growth. Stalk length at 40 DAT and 60 DAT was found non significantly recorded due to minute effect of both growth regulators. Highest stalk length was recorded in treatment GA_3 @ 60 ppm (3.07 cm) at 40. At 60 DAT highest stalk length was recorded in treatment GA_3 @ 60 ppm (3.37 cm). Similar result reported by Sitapara *et al.* (2011) [11] and Meena *et al.* (2018) [5]. Maximum head diameter at 40 DAT (12.3 cm) was noticed under treatment (NAA @ 25 ppm),while at 60 DAT (19.0 cm) it was noticed under treatment (GA_3 @120 ppm). Vijay and Ray (2000), Meena and Dhaka (2003) [4], Patil *et al*. (2003), Lendve *et al.* (2010) [3], Kotecha *et al*. (2011) [2] and Vishwakarma *et al*. (2017) [13]. Minimum days (32.9) required from transplanting to initiation of head formation were observed in treatment GA_3 @ 120 ppm treatment and maximum days taken for initiation of head formation was recorded with control (37.7).Minimum days (61.3) required for complete maturity of head was observed in treatment GA_3 @ 120 ppm treatment and maximum days taken for complete maturity of head formation was recorded with control (68.7). Similar results were also reported by Sawant *et al.* (2010) [10] and Thapa *et al* (2013) [12].

Table 1: Plant height, Plant spread(cm^2), No. of non wrapping leaves, Stalk length, Head diameter (cm), Initiation of head and Complete maturity of head.

Treatments	Plant Height (cm)		Plant Spread (cm^2)		No. of Non wrapping leaf		Stalk length (cm)		Head diameter (cm)		Initiation of head	Complete maturity of head
	40 DAT	60 DAT	40 DAT	60 DAT	40 DAT	60 DAT	40 DAT	60 DAT	40 DAT	60 DAT	Days	Days
T1.GA_3 (30ppm)	15.7	19.3	1540.5	1999.3	11.3	11.9	2.80	2.93	10.7	17.4	36.1	65.7
T2.GA_3 (60ppm)	14.3	17.5	1592.7	2030.0	12.3	12.7	3.07	3.37	10.6	16.9	34.1	62.8
T3.GA_3 (90ppm)	14.6	19.0	1633.1	2064.4	13.1	13.7	2.45	2.68	11.8	18.3	33.5	61.8
T4.GA_3(120ppm)	14.7	19.1	1718.0	2073.0	11.1	12.3	2.54	2.74	11.9	19.0	32.9	61.3
T5.NAA (25ppm)	14.8	18.5	1518.7	1993.7	11.2	12.5	2.41	2.70	12.3	18.0	36.7	65.3
T6.NAA (50ppm)	14.2	17.3	1572.8	2007.7	10.9	12.1	2.74	2.98	11.5	16.1	34.6	63.0
T7.NAA (75ppm)	14.6	18.4	1600.3	2019.0	11.2	11.9	2.98	3.23	11.7	16.8	34.5	62.4
T8.NAA (100ppm)	14.1	16.9	1656.3	2044.5	10.7	11.5	2.51	2.75	11.4	16.0	34.3	62.7
T9.Control	13.9	16.7	1443.3	1877.7	10.0	11.2	2.39	2.60	10.1	15.4	37.7	68.7
SE m ±	0.43	0.56	8.53	7.443	0.45	0.45	0.21	0.21	0.43	0.64	0.8	1.07
C.D. (5%)	NS	1.68	25.59	22.31	1.37	1.35	NS	NS	1.30	1.92	2.28	3.21

Table 2: Yield and yield attributes of Cabbage

Treatments	Fresh weight of cabbage heads (g)	Dry weight of cabbage head (g)	Yield per plot (kg)	Yield per hectare (q)
T1.GA_3 (30ppm)	1154.0	84.7	25.6	341.1
T2.GA_3 (60ppm)	1333.3	92.0	26.5	353.5
T3.GA_3 (90ppm)	1345.7	94.3	28.1	375.2
T4.NAA(120ppm)	1399.7	103.7	30.5	407.0
T5.NAA (25ppm)	1001.7	83.7	27.4	365.3
T6.NAA (50ppm)	1273.3	89.0	26.4	352.2
T7NAA (75ppm)	1298.3	91.3	29.5	393.6

T8.NAA(100ppm)	1335.0	93.0	30.0	399.8
T9.Control	943.7	70.7	25.5	339.9
SE m ±	7.54	1.63	0.952	0.931
C.D. (5%)	22.62	4.89	2.856	2.792

All yield and yield attributes characters *viz*. Fresh weight of cabbage heads (g), dry weight of cabbage head (g), Yield per plot (kg)and Yield per hectare (q).were analyzed and significantly highest fresh weight of cabbage head (1399.7) was recorded in treatment with GA_3 @ 120 ppm and minimum fresh weight of cabbage head was recorded for control (943.7). Reza *et al*. (2015) [8] and Vishwakarma *et al.* (2017) [13]. Significantly highest dry weight of cabbage head 103.7 was recorded in treatment with GA_3 @ 120 ppm and minimum dry weight of cabbage head was recorded in control (70.7). Minimum dry weight of cabbage head was recorded in control (70.7).

Significantly highest yield per plot of cabbage 30.5 kg was recorded in treatment with GA_3 @ 120 ppm which was at par with NAA @ 100 ppm (30 kg), NAA @ 75 ppm (29.5 kg) and minimum yield per plots was recorded withcontrol (25.5 kg). Similar findings were reported by Sawant *et al.* (2010) [10] and Roy and Nasiruddin (2011) [9].

Significantly highest yield per hectare of cabbage head was recorded in treatment with GA_3 @ 120 ppm (407 qha^{-1}) and minimum yield per plots was recorded for control (339.9 qha^{-1}). Similar results were reported by Majumdar (2013) [4], Chaurasiy *et al.* (2014). On the basis of said results it can be concluded that treatment GA_3 treatment GA_3 – 120 ppm foliar spray can enhance the yield and yield attributes of cabbage

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