Research Journal of Agricultural Sciences
An International Journal

Res. Jr. of Agril. Sci. **12**(2): 713–716

P- ISSN: 0976-1675 | **E**- ISSN: 2249-4538

www.rjas.org

Research Paper

Effect of Integrated Nutrient Management, Cycocel and Crop Geometry on Morphological Features and Yield of Cabbage (*Brassica oleracea* L. var. *capitata*) in Bundelkhand Region

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Received: 01 Mar 2021 | Revised accepted: 24 Apr 2021 | Published online: 27 Apr 2021

A B S T R A C T

In the diversified farming system, integrated nutrient management under different crop geometry along with growth regulators is the most appropriate approach to solve various issues related to productivity, quality as well as sustainability in efficient and economic way. Cabbage is well known for its nutritive and health benefits. A field experiments were conducted to study the effect of vermicompost, inorganic fertilizers and growth retardant (cycocel) with different spacing on cabbage carried out in factorial randomized block design at Experimental Farm of Bundelkhand University, Jhansi (U.P.) during rabi season 2017-18 and 2018-19. Results indicated that yield and yield contributing components of cabbage cultivar Pusa Drum Head were found to be highest and significant in the treatment where 50% RDF (Inorganic Fertilizer) + 50% Organic (vermicompost) were applied at wider crop geometry (45cm × 45cm spacing) along with spraying of 300 ppm cycocel (growth retardant). The head yield of cabbage was positively correlated with various yield components. Application of vermicompost along with inorganic fertilizers with cycocel treatment reduce the days taken to head maturity. The experimental findings indicated that reduction in the amount of inorganic fertilizer was not detrimental to total yield to cabbage. So, 50% doses of recommended fertilizer would be supplemented with vermicompost. It is also evident that integration of vermicompost and inorganic fertilizer at wider spacing under cycocel treatment enhances the productivity of cabbage beside sustaining soil fertility status.

***Key words*:** Cabbage, Vermicompost, Fertilizer, Cycocel, Spacing, Yield

The significance of balanced nutrient application is well adopted by farmers for increasing crop productivity. In the diversified farming system, integrated nutrient management under different crop spacing along with growth regulators is the most appropriate approach to solve various issues related to productivity, quality as well as sustainability. Cabbage is well known for its nutritive and health benefits. It has four distinct uses viz. salads, boiling, pickling and sauerkraut. Cabbage is grown during winter as a major vegetable crop and during summer it is taken as a minor crop or intercrop in Uttar Pradesh. This crop being a grossly feeder, is always been in a high requirement of nutrients for producing best quality and productivity. On the other hand, its productivity is very low in spite of showing great potential in the state. In Uttar Pradesh the production of cabbage is around 302.97 thousand MT from an area of 9.06 thousand hectare with the productivity of 33.44 t/ha [1]. Therefore, keeping in view, the field experiments were conducted in Bundelkhand region to study the effect of vermicompost, inorganic fertilizers and growth retardant (cycocel) with different spacing on cabbage.

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MATERIALS AND METHODS

The present study was conducted at Experimental Farm of Bundelkhand University, Jhansi (U.P.) during *rabi* season 2017-18 and 2018-19, Geographically, the research farm of the university is located at 25.45ºN latitude and 78.61ºE longitude at an altitude of 285 m from mean sea level having a sub-tropical climate. The Investigation was laid out in factorial randomized block design with 27 treatment combinations and three replications. The experiment comprised of three different factors such as 1. Cycocel viz. C_1 (0 ppm), C_2 (300 ppm) and C_3 (600 ppm) 2. Fertilizer application viz. F_1 (100% RDF Inorganic Fertilizer 120:80:60 NPK kg/ha), F_2 (75% RDF Inorganic Fertilizer + 25% Organic Vermicompost) and F_3 (50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost)) 3. Plant spacing viz. S_1 (30 × 30 cm), S_2 (45 × 30 cm) and S_3 (45 × 45 cm). The observation recorded on plant height, number of open leaves, days taken to head maturity, yield and yield attributes such as weight of diameter of head and head yield. All the agronomic were followed as recommended to the crop. One month old cabbage seedlings of Pusa Drum Head were transplanted in the main field at different spacing. Biometrical observations of five randomly samples were taken from each treatment with standard procedures and techniques. Data recorded were analyzed with the help of statistical programme- STPR- 3

developed by Department of Mathematics and Statistics, College of Basic Science and Humanities, GBPUAT, Pantnagar, Uttarakhand, India.

RESULTS AND DISCUSSION

Two years pooled data shown in (Table 1) revealed that maximum plant height at 60 days was found maximum (48.19 cm) in treatment $C_1F_3S_3$ which was statistically at par with $C_1F_3S_2$. The finding indicated that application of 50% vermicompost in combinations with 50% inorganic fertilizers at wider spacing significantly affected the plant height of cabbage. This effect might be attributed to the solubilisation of plant nutrients by addition of vermicompost leading to subsequent uptake of NPK by plant. In wider spaced crop proliferous root system developed under above circumstances resulting better absorption of water and nutrients with improved physical environment of soil [2-4]. Plant height decreased slightly with increasing the cycocel concentration. Plants treated with cycocel were slightly shorter than the controlled plants (C_1). This might be due to the cycocel affected the transport of carbohydrate to the roots via decreasing plant height. The findings are in similar lines with [5] while the maximum numbers of open leaves (19.40) per plants were recorded in $C_2F_3S_3$ which was non-significant with $C_2F_3S_2$. The response of 50% vermicompost in combination with 50% inorganic fertilizers was found to be higher in number of leaves at wider spaced crop (45×45 cm and 45×30 cm) as compare to the least spaced crop (30×30 cm). This might be due to integration of organic and inorganic fertilizer which might have appeared complementary and supplementary regarded to each other and exhibited into continuous supply of nutrients. Vermicompost imparts favourable soil structure for better root growth, which ultimately increase number of leaves. The higher number of open leaves might also be increased slightly by the reduction in intermodal length which might be affected by cycocel treatments [6-9].

Table 1 Effect of integrated nutrient management, cycocel and crop geometry on vegetative characters of cabbage

(Two years pooled)

Treatments	Treatment combinations	Plant height (cm) at 60 days	No. open leaves per plant	Thickness of main stem (mm)	Plant spread (cm)
$C_1F_1S_1$	0 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 30x30 cm spacing	41.51	16.90	35.39	64.24
$C_1F_1S_2$	0 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x30 cm spacing	45.10	17.47	36.05	64.50
$C_1F_1S_3$	0 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x45 cm spacing	46.08	17.67	35.09	64.44
$C_2F_1S_1$	300 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 30x30 cm spacing	41.79	17.53	34.27	63.66
$C_2F_1S_2$	300 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x30 cm spacing	43.73	17.77	34.54	63.77
$C_2F_1S_3$	300 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x45 cm spacing	45.45	17.87	33.31	63.66
$C_3F_1S_1$	600 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 30x30 cm spacing	39.13	16.60	31.64	61.22
$C_3F_1S_2$	600 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x30 cm spacing	42.10	17.07	32.47	62.74
$C_3F_1S_3$	600 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x45 cm spacing	41.79	17.60	35.79	63.15
$C_1F_2S_1$	0 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 30x30 cm spacing	46.54	17.83	40.42	65.91
$C_1F_2S_2$	0 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x30 cm spacing	46.46	18.07	40.66	66.90
$C_1F_2S_3$	0 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x45 cm spacing	46.54	18.33	41.04	66.45
$C_2F_2S_1$	300 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 30x30 cm spacing	43.85	18.03	40.55	65.78
$C_2F_2S_2$	300 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x30 cm spacing	43.85	18.33	40.25	66.32
$C_2F_2S_3$	300 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x45 cm spacing	44.94	18.80	41.26	66.12
$C_3F_2S_1$	600 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 30x30 cm spacing	40.86	17.43	40.62	64.62
$C_3F_2S_2$	600 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x30 cm spacing	40.86	18.07	38.17	65.25
$C_3F_2S_3$	600 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x45 cm spacing	40.94	18.77	38.19	68.74
$C_1F_3S_1$	0 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 30x30 cm spacing	47.17	17.33	41.40	69.28
$C_1F_3S_2$	0 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x30 cm spacing	48.10	18.30	41.80	70.85
$C_1F_3S_3$	0 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing	48.19	18.80	42.57	69.18
$C_2F_3S_1$	300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 30x30 cm spacing	43.33	18.40	41.78	69.29
$C_2F_3S_2$	300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x30 cm spacing	44.35	18.90	42.56	71.59
$C_2F_3S_3$	300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing	45.44	19.40	43.27	70.20
$C_3F_3S_1$	600 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 30x30 cm spacing	40.84	18.03	41.50	68.07
$C_3F_3S_2$	600 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x30 cm spacing	41.92	18.27	41.36	71.18
$C_3F_3S_3$	600 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing	43.22	18.57	43.28	70.92
	SEm	0.02	0.07	0.05	0.21
	CD	0.07	0.21	0.15	0.59

The different level of integrated nutrient management and crop geometry brought out significant response in thickness of main stem at 60 days after transplanting (DAT). The maximum thickness of main stem were recorded in treatment $C_2F_3S_3$ (43.27 mm) which was statistically at par with $C_3F_3S_3$ while minimum was observed in $C_3F_1S_1$ (31.64 mm). The development of plant is reflected through the increase in thickness of main stem which was caused because of the ceaseless accessibility of supplements. The expansion in stem thickness with vermicompost and inorganic fertilizers might be because of more number of leaves and total leaf surface, which lead to increment in photosynthesis. The use of vermicompost in combination with inorganic fertilizers might have considerably improved the availability of macro and micro nutrients in the soil, as result of which stem thickness has been boosted. In addition to the inhibitory effect of higher dose of cycocel on cell elongation the stem might grown horizontally which ultimately increase the thickness of main stem [10-12]. With regard to plant spread the maximum plant spread were recorded in treatment $C_2F_3S_2$ (71.59 cm) which was statistically at par with $C_3F_3S_2$. Use of vermicompost with inorganic fertilizers (RDF) improved the uptake of essential elements. It is because of proliferous root framework created under wide crop geometry which provides better assimilation of water and supplements with improved actual conditions of soil amended by 50% vermicompost along-with 50%

inorganic fertilizers. This impact could be ascribed to the solubilisation of nutrients which accelerate the photosynthetic activity and secretion of growth promoting substances viz., IAA, kinetin, riboflavin and thiamine which result in better plant spread. In addition, application of cycocel also enhances better plant spread which might be due to reduction in vertical growth [13-15].

A perusal of data in (Table 2) revealed that the different level of integrated nutrient management and crop geometry brought out non-significant response in days taken to head initiation. However, the minimum days taken to head initiation was observed in treatment $C_2F_3S_3$(64.65 days) whereas, maximum days taken to head initiation was recorded in treatment $C_1F_1S_1$ (69.83 days). The decrease in days taken to head initiation with the application of vermicompost and cycocel might be due to verms plays significant role in supply of all essential nutrients [16-17].

In terms of days taken to head maturity from planting the minimum days taken to head maturity was also observed in treatment $C_2F_3S_3$ (75.87 days) which was statistically non-significant with $C_2F_3S_2$ and $C_3F_3S_3$ whereas, maximum days taken to head initiation was recorded in treatment $C_1F_1S_3$ (86.47 days). In general, the integration of cycocel has significantly reducing the time taken for maturation of head under wide spaced crop nourished with 50% vermicompost + 50% inorganic fertilizers. This might be due to increase in dry matter production during the earlier growth stages because of readily availability of essential nutrient in the soil. The results are in conformity with the findings of [18] in brinjal, [19] in capsicum and [20] reported that the plants treated with cycocel plant growth retardant produced the more compact growth and earlier flower bud initiation in chrysanthemum.

The maximum head size (14.76 cm) was obtained with application of 50% organic manure (vermicompost) + 50% inorganic fertilizer at wider spaced crop (45×45 cm) with higher dose of cycocel (600 ppm) while minimum head size was recorded in $C_1F_1S_1$ (100% RDF inorganic fertilizers). The increase in head size might be due to the retardation of stem elongation exerted by cycocel which preventing the formation of kaurene, a precursor of gibberellins biosynthesis, subsequently inhibiting or reducing the elongation of stem cells [21-22].

Table 2 Effect of integrated nutrient management, cycocel and crop geometry on days taken to head initiation, head maturity, head size and yield of cabbage

Treatments	Treatment combination	Days taken to head initiation (Days)	Days taken to head maturity from planting (Days)	Head size (cm)	Yield (kg/plant)	Yield (q/ha)
$C_1F_1S_1$	0 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 30x30 cm spacing	69.83	85.73	12.11	0.570	868.52
$C_1F_1S_2$	0 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x30 cm spacing	69.53	84.33	12.53	0.950	591.36
$C_1F_1S_3$	0 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x45 cm spacing	69.58	86.47	12.57	1.013	477.94
$C_2F_1S_1$	300 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 30x30 cm spacing	69.16	83.87	13.05	0.953	1055.74
$C_2F_1S_2$	300 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x30 cm spacing	68.74	82.73	13.25	1.152	880.25
$C_2F_1S_3$	300 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x45 cm spacing	68.62	82.17	13.27	1.438	862.54
$C_3F_1S_1$	600 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 30x30 cm spacing	69.16	80.40	13.07	0.945	1107.41
$C_3F_1S_2$	600 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x30 cm spacing	68.58	81.87	13.33	1.263	1317.28
$C_3F_1S_3$	600 ppm CCC + 100% RDF Inorganic Fertilizer (120:80:60 NPK kg/ha) with 45x45 cm spacing	68.53	81.33	13.55	1.550	861.72
$C_1F_2S_1$	0 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 30x30 cm spacing	69.41	84.87	12.57	1.525	1091.30
$C_1F_2S_2$	0 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x30 cm spacing	69.12	83.10	13.09	0.958	880.25
$C_1F_2S_3$	0 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x45 cm spacing	69.03	83.43	13.13	1.005	587.65
$C_2F_2S_1$	300 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 30x30 cm spacing	68.53	81.73	13.59	1.093	1203.70
$C_2F_2S_2$	300 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x30 cm spacing	67.83	81.07	13.71	1.382	1237.04
$C_2F_2S_3$	300 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x45 cm spacing	67.37	80.60	13.77	1.858	1040.31
$C_3F_2S_1$	600 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 30x30 cm spacing	68.08	83.07	13.63	1.402	1157.41
$C_3F_2S_2$	600 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x30 cm spacing	64.81	76.60	13.97	1.815	1298.76
$C_3F_2S_3$	600 ppm CCC + 75% RDF Inorganic Fertilizer + 25% Organic (Vermicompost) with 45x45 cm spacing	65.78	77.47	14.01	2.117	1000.81
$C_1F_3S_1$	0 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 30x30 cm spacing	69.41	85.13	12.83	1.612	1098.15
$C_1F_3S_2$	0 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x30 cm spacing	68.74	84.33	13.19	1.368	899.26
$C_1F_3S_3$	0 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing	68.83	83.43	13.25	1.470	1004.10
$C_2F_3S_1$	300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 30x30 cm spacing	65.35	76.60	14.25	1.068	1257.41
$C_2F_3S_2$	300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x30 cm spacing	65.03	76.10	14.64	1.863	1243.21
$C_2F_3S_3$	300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing	64.65	75.87	14.72	3.030	1437.84
$C_3F_3S_1$	600 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 30x30 cm spacing	65.62	78.50	14.31	1.800	1396.29
$C_3F_3S_2$	600 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x30 cm spacing	64.99	76.63	14.68	1.753	1387.65
$C_3F_3S_3$	600 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing	65.07	76.17	14.76	2.733	1291.34
	SEm	0.40	0.37	0.01	0.03	25.28
	CD	NS	1.04	0.03	0.07	71.76

The data shown in (Table 2) expressed that the different level of integrated nutrient management and crop geometry brought out significant response for yield. The maximum significant yield (kg/head) were observed in treatment $C_2F_3S_3$ (3.030 kg) followed by $C_3F_3S_3$ (2.733 kg) whereas, minimum significant yield was recorded in treatment $C_1F_1S_1$ (0.570 kg). The highest per hectare yield were observed in treatment $C_2F_3S_3$ (1437.84 q/ha) which was statistically at par with $C_3F_3S_1$ and $C_3F_3S_2$ while the per hectare yield were recorded minimum in treatment $C_1F_1S_3$ (477.94 q/ha).

Application of vermicompost might have considerably increases the availability of macro and micro elements in soil which exerted more yield. The considerable positive increase in yield parameters on account of vermicompost and inorganic fertilizers along with cycocel spray might have resulted to the translocation of nutrients from soil particularly at later stage of crop growth. Application of cycocel increase the growth regulator substance like cytokine in which resulted in enhances the amount of leaf chlorophyll. Then the vegetative growth was efficient to synthesize the improved amount of

carbohydrate assimilated by the enhanced rate of photosynthesis. Further increased vegetative growth might have provided more sites for translocation of photosynthesis, which ultimately resulted in increased yield. The plants planted under wider spacing showed more nutrients uptake, light and moisture around compared to plants of narrower spacing, which was possibly the reason of better performance in yield characters and yield of individual cabbage head [23-25].

CONCLUSION

On the basis of present investigation, it can be concluded that treatment $C_2F_3S_3$ (300 ppm CCC + 50% RDF Inorganic Fertilizer + 50% Organic (Vermicompost) with 45x45 cm spacing) performed best in producing higher vegetative growth and yield of cabbage than the other treatments comprised with different levels of cycocel, fertilizer and plant spacing under the present study. It can be further stated that the integrated approach of organic and inorganic fertilization at wider spacing enhances the productivity of cabbage besides sustaining soil fertility.

Acknowledgement

Authors are very grateful to Hon'ble Vice- Chancellor of Bundelkhand University, Jhansi, U.P. and Academic coordinator, Institute of Agricultural Sciences, Bundelkhand University campus, Jhansi for providing necessary facilities.

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