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Effect of different doses of nitrogen, phosphorous and vermicompost on growth and yield of garlic (*Allium sativum* L.)

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Abstract
The work was carried out during the years 2015-2016 at experimental field of RRS (OAZ), UBKV to study the effect of different organic and inorganic nutrient combination on garlic production using two variety viz. Gangajali and Katki. The experiment was carried out in a completely randomized design with three replicates. The treatments consisted of four levels of nitrogen (0, 50, 100, 150 Kg ha^{-1}), three levels of phosphorus (0, 50, 100 Kg ha^{-1}) and two levels of vermicompost (0, 10 tons ha^{-1}). From different treatment combinations of NPV, the leaf number increased with the increasing level of both nitrogen and vermicompost. The treatment $N_2P_1V_1$ (recommended dose of NPV 150:50:10) was found for increase bulb weight, bulb diameter in respect of higher bulb yield in both the variety. The effect of vermicompost also significantly ($P < 0.05$) influenced plant height, leaf number, mean bulb weight, bulb diameter and total bulb yield. From the character association studies it was revealed that leaf breadth, bulb weight and bulb diameter were significant and positive association with bulb yield among both the varieties.

Keywords: Garlic, inorganic, organic fertilizer, vermicompost, yield

Introduction
Garlic is one of the important and widely cultivated spice crops used for food as well as medicinal purposes (Diriba *et. al.,* 2013) [1]. It is highly accepted for its flavour enhancing capacity. It adds to taste of foods as well as it helps to make them digestible. Garlic possesses antimicrobial, anticarcinogenic and antimutagenic properties. Garlic's volatile oil has many sulphur containing compounds that are responsible for the strong odour, its distinctive flavour and pungency as well as for its health benefit. It is rich in sugar, protein, fat, calcium, potassium, phosphorous, sulfur, iodine fiber and silicon in addition to vitamins. Furthermore, garlic has miracle pharmaceutical effects and used to cure an enormous disease including blood pressure and cholesterol, cancer, hepatoprotective, antihelmentics, antiinflammatory, antioxidant, antifungal and wound healing, asthma, arthritis, sciatica, lumbago, backache, bronchitis, chronic fever, tuberculosis, rhinitis, malaria, obstinate skin disease including leprosy, leucoderma, discoloration of the skin and itches, indigestion, colic pain, enlargement of spleen, piles, fistula, fracture of bone, gout, urinary diseases, diabetes, kidney stone, anemia, jaundice, epilepsy, cataract and night blindness. There are many essential nutrients which are required to promote plant growth and development but nitrogen, phosphorus and potash are needed in larger quantities. Garlic is heavy feeder and most of the *Allium* species have low nutrient extraction capacity than most crop plants because of their shallow and un-branched root system. Availability of nitrogen is of prime importance for growing plants as it is a major and indispensable source of protein and nucleic acid molecules. Phosphorus is also a key element for vegetables as it stimulates the root formation and centre for the components of nucleic acid and the bulb formation. An integrated application of alternate sources of nutrients is urgent required for sustaining the desired crop productivity. Vermicompost is one of the important organic manure sources which can be used to increase the soil fertility. On the other hand, vermicompost increases the bulb dry weight by the accumulation of non structured carbohydrates whole distribution patterns change, thus favoring the metabolism of fructan precursors and accumulating as scorodose (Juan *et. al.,* 2006) [2]. Keeping this in view, the present investigation was undertaken to find out the interaction effect of nitrogen and phosphorous and vermicompost on growth and yield of garlic.

Materials and Methods

The experiment was conducted at Instruction farm, RRS, UBKV, Majhian, Dakshin Dinajpur, W.B, India. There were twenty four treatment combinations of nitrogen, phosphorus and vermicompost were used. The treatments consisted of four levels of nitrogen (0, 50, 100, 150 Kg ha^{-1}), three levels of phosphorus (0, 50, 100 Kg ha^{-1}) and two levels of vermicompost (0, 10 tons ha^{-1}). The experiment was laid out as a randomized complete block design in a factorial arrangement with three replications using and two varieties (Gangajali and Katki) of garlic. Nitrogen in the form of urea (46% N) was applied ¼ at planting, while the remaining ½ and ¼ were side-dressed three and six weeks, respectively, after plant emergence. The experimental plot was regularly observed and the observations on vegetative parameters were recorded at 120 days after planting from ten plants. The statistical analysis of experimental data was done by SPSS var.16 software. The twenty four treatment combination of nitrogen, phosphorous and vermicompost ($N_0P_0V_0$, $N_1P_0V_0$, $N_2P_0V_0$, $N_3P_0V_0$, $N_0P_1V_0$, $N_1P_1V_0$, $N_2P_1V_0$, $N_3P_1V_0$, $N_0P_2V_0$, $N_1P_2V_0$, $N_2P_2V_0$, $N_0P_0V_1$, $N_1P_0V_1$, $N_2P_0V_1$, $N_0P_1V_1$, $N_1P_1V_1$, $N_2P_1V_1$, $N_3P_1V_1$, $N_0P_2V_1$, $N_1P_2V_1$, $N_2P_2V_1$, $N_3P_2V_1$) were presented in following-

Nitrogen doses	Phosphorous doses	Vermicompost doses
N_0 – 0 kg ha^{-1}	P_0 – 0 kg ha^{-1}	V_0 – 0 t/ha
N_1 – 50 kg ha^{-1}	P_1 – 50 kg ha^{-1}	V_1 – 10 t/ha
N_2 – 100 kg ha^{-1}	P_2 - 100 kg ha^{-1}	
N_3 – 150 kg ha^{-1}		

Result and Discussion

The data presented in Table 1 and 2, showed the significant variations almost all the growth and yield characteristics of garlic. Data regarding on different characters of ten sampled plant was taken at 30 DAP and 120 DAP and the mean value of characters for both the variety of garlic has been presented in Table 1 and 2. The analysis of variance indicated that the plant height was significantly affected with application of different treatment combinations of NPV. The increasing trend of plant height was observed with the increasing level of nitrogen upto a certain extent *i.e.* from zero 50 kg ha^{-1} to 150 kg ha^{-1} along with application of vermicompost. The maximum plant height was recorded in Gangajali by the treatment at $N_1P_0V_0$ (27.75 cm) followed by $N_2P_0V_1$ (27.06 cm), $N_1P_0V_1$ (26.79 cm), while least found in $N_3P_1V_1$ and for Katki maximum plant height at $N_1P_0V_1$ (27.87 cm) followed by $N_1P_0V_0$ (27.75 cm) and $N_2P_0V_1$.

In respect of leaf number, the significant variations were observed in sole effect of both nutrients and their interactions also. The leaf number increased with the increasing level of both nitrogen and vermicompost. Data regarding on leaves $plant^{-1}$ of ten sampled was counted at 30 DAP. The maximum numbers of leaves $plant^{-1}$ was found in Gangajali at $N_1P_0V_1$ (4.80) followed by $N_3P_0V_1$ (4.73), $N_0P_1V_1$ (4.40), while minimum was found in $N_1P_2V_1$ (3.47) where as $N_1P_1V_1$ followed by $N_2P_0V_1$ and $N_3P_2V_1$ in Katki. Among all combination of treatment maximum length of leaves (cm) was recorded in $N_1P_2V_1$ (24.26 cm), followed by $N_2P_0V_1$ (24.19 cm), $N_1P_0V_1$ (23.65 cm), while least was found in control $N_0P_2V_0$ (19.81cm) in Gangajali and $N_1P_0V_1$ followed by $N_3P_0V_0$ in Katki. Significant affect was found in breadth of leaves (cm) by the application of different treatment combinations of NPV. The maximum breadth of leaves was found in $N_1P_0V_1$ (1.80cm) followed by $N_2P_2V_0$ (1.50 cm), $N_3P_1V_1$ (1.50cm) in Gangajali, while least was found in control $N_0P_1V_0$ (0.65cm) and $N_2P_2V_1$ followed by $N_1P_0V_1$ and $N_2P_0V_1$ in Katki. From nutrient combinations, the higher levels of nitrogen along with intermediate level of phosphorous (50 kg ha^{-1}) gained maximum bulb weight with increase bulb diameter. The maximum weight of bulb (g) was recorded in Gangajali at $N_2P_1V_0$ (12.80 g.) followed by $N_1P_1V_1$ (12.70 g.), $N_2P_1V_1$ (12.70 g.), and for Katki maximum by $N_2P_1V_0$ followed by $N_2P_1V_1$ and $N_1P_2V_1$. The maximum diameters of bulb was recorded in $N_2P_2V_1$ (3.5 cm) followed by $N_1P_2V_1$ (3.4 cm), $N_2P_1V_1$ (3.4 cm) in Gangajali, while in Katki at $N_2P_1V_1$ followed by $N_2P_1V_1$ and $N_1P_2V_1$. Maximum bulb yield was found by combination of different treatments in Gangajali at $N_2P_1V_1$ followed by $N_2P_2V_1$ and $N_3P_2V_1$ and in Katki at $N_2P_1V_1$ followed by $N_2P_2V_1$ and $N_3P_0V_1$. It was clear from the data that parameters were also affected by the application of different treatment combination of NPV.

From this experiment, it is clear confirmation that response of nitrogen upto 150 kg N ha^{-1} and adverse effect of higher dose of nitrogen *i.e.*, 250 kg ha^{-1} has been observed. The adverse effect of N beyond 150 Kg N ha^{-1} also reported earlier (Buwalda and Frederikson, 1985; Ruiz, 1986) [3, 4]. The application of 150 kg N ha^{-1} a significantly increased the growth attributes like plant height, leaf number, breadth of leaf and yield parameters like bulb weight, number of cloves per bulb, diameter of bulb and yield (Hore *et al*., 2014; Naruka and Dhaka, 2001; Yadav, 2003; Farooqui *et al*., 2009) [5, 6, 7, 8]. Availability of nitrogen is of prime importance for growing plants as it is major and indispensable constituent of protein and nucleic acid molecules. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally leading to higher productivity. Response of garlic to higher dose of nitrogen also reported from different parts of the world. The main effect of phosphorus 50 kg N ha^{-1} significantly influenced all growth parameters except leaf number. From both the variety it was evident that plant height, leaves per plant, cloves per bulb, polar diameter of bulb, equatorial diameter of bulb, fresh weight of bulb, dry weight of bulb and bulb yield increased significantly due to application of vermicompost. The above finding clearly indicated that vermicompost as well as nitrogen application played a significant role in enhancing the growth and yield of garlic. Due to application of vermicompost in soil improved nutrient availability and improvement in physical condition of soil which provides balanced nutritional environment both in soil rhizosphere and plant system. The increase in bulb yield with application of vermicompost was in conformity with the earlier findings (Suthar, 2008; Shashidhar *et al*., 2009; Rodriguez *et al*., 2012; Verma *et al*., 2013) [9, 10, 11, 12]. From the character association studies it was revealed that leaf breadth, bulb weight and bulb diameter were significant and positive associated with bulb yield among both the varieties (Table 3 and 4).

Table 1: Effect of different treatment combination of nitrogen, phosphorous and vermicompost on growth and yield characteristics of Garlic cv. Gangajali

Treatments	Plant height	Leaf no.	Leaf length	Leaf breadth	Bulb weight	Bulb diameter	Yield plot^{-1}	Yield/ha
$N_0P_0V_0$	25.83	4.13	22.29	0.79	8.10	2.70	0.69	2.30
$N_1P_0V_0$	27.75	4.27	24.97	0.77	9.20	3.00	0.81	2.70
$N_2P_0V_0$	25.45	3.87	21.83	0.92	11.50	3.00	0.84	2.80
$N_3P_0V_0$	25.75	4.00	23.52	0.87	12.60	3.10	0.84	2.80
$N_0P_1V_0$	25.89	3.93	23.61	0.65	7.80	2.90	0.83	2.77
$N_1P_1V_0$	23.05	4.00	20.91	0.82	10.60	3.00	0.96	3.20
$N_2P_1V_0$	23.81	4.33	21.44	0.94	12.80	3.10	1.02	3.40
$N_3P_1V_0$	23.77	4.27	21.69	1.20	11.10	3.50	0.99	3.30
$N_0P_2V_0$	23.08	3.80	19.81	0.76	8.30	3.00	0.84	2.80
$N_1P_2V_0$	25.67	3.80	21.69	0.92	9.60	3.10	1.05	3.50
$N_2P_2V_0$	25.62	4.20	22.61	1.50	12.40	3.20	1.05	3.50
$N_3P_2V_0$	25.67	3.93	22.77	1.40	12.10	3.23	0.96	3.20
$N_0P_0V_1$	26.70	3.60	23.49	0.92	8.40	3.00	0.90	3.00
$N_1P_0V_1$	26.79	4.80	23.65	1.80	8.80	2.90	0.96	3.20
$N_2P_0V_1$	27.06	3.93	24.19	1.40	9.50	3.10	1.05	3.50
$N_3P_0V_1$	24.63	4.73	22.62	1.20	9.40	2.90	1.05	3.50
$N_0P_1V_1$	23.35	4.40	21.23	0.95	10.60	3.10	0.93	3.10
$N_1P_1V_1$	22.69	3.87	20.55	1.40	12.70	3.20	1.02	3.40
$N_2P_1V_1$	23.49	3.93	21.01	1.30	12.70	3.60	1.16	3.70
$N_3P_1V_1$	22.55	4.00	20.08	1.50	11.40	3.40	1.05	3.50
$N_0P_2V_1$	24.09	4.13	22.45	0.76	9.70	3.10	0.87	2.90
$N_1P_2V_1$	27.89	3.47	24.26	0.96	11.80	3.80	1.06	3.50
$N_2P_2V_1$	24.78	3.80	21.84	1.50	12.70	3.70	1.13	3.72
$N_3P_2V_1$	24.08	4.07	21.84	1.40	11.43	3.57	1.01	3.36
C.D. (P=0.05)	2.331	0.622	1.835	0.016	0.026	0.027	0.016	0.031
SE(m)	0.816	0.218	0.643	0.006	0.009	0.009	0.006	0.011
SE(d)	1.154	0.308	0.909	0.008	0.013	0.013	0.008	0.015
C.V.	5.699	9.305	5.028	0.869	0.149	0.516	1.04	0.591

Table 2: Effect of different treatment combination of nitrogen, phosphorous and vermicompost on growth and yield characteristics of Garlic cv. Katki

Treatments	Plant height	Leaf no.	Leaf length	Leaf breadth	Bulb weight	Bulb diameter	Yield plot^{-1}	Yield/ha
$N_0P_0V_0$	25.48	3.60	22.89	0.67	6.20	2.50	0.54	1.80
$N_1P_0V_0$	27.75	3.87	22.73	0.68	7.10	2.80	0.63	2.10
$N_2P_0V_0$	25.17	3.73	23.23	0.76	8.40	2.80	0.60	2.00
$N_3P_0V_0$	25.11	3.80	23.34	0.75	9.60	2.80	0.67	2.20
$N_0P_1V_0$	24.34	3.93	22.04	0.65	6.00	2.70	0.68	2.27
$N_1P_1V_0$	22.67	3.47	20.53	0.70	8.60	2.80	0.81	2.70
$N_2P_1V_0$	23.62	3.33	20.28	0.82	10.80	2.90	0.87	2.90
$N_3P_1V_0$	24.89	4.00	22.57	1.08	9.10	3.30	0.84	2.80
$N_0P_2V_0$	20.65	3.40	18.57	0.64	6.30	2.80	0.69	2.30
$N_1P_2V_0$	25.40	3.80	23.15	0.80	7.60	2.90	0.84	2.80
$N_2P_2V_0$	24.73	3.67	22.08	1.08	10.40	2.97	0.90	3.00
$N_3P_2V_0$	23.61	3.27	20.61	1.28	10.10	3.00	0.81	2.70
$N_0P_0V_1$	23.36	3.33	20.99	0.76	6.40	2.80	0.78	2.60
$N_1P_0V_1$	27.87	4.00	24.00	1.28	6.80	2.70	0.81	2.70
$N_2P_0V_1$	26.35	4.20	23.22	1.28	7.50	3.20	0.90	3.00
$N_3P_0V_1$	23.25	3.87	21.36	1.08	7.40	2.70	0.96	3.20
$N_0P_1V_1$	23.63	3.80	21.44	0.83	8.60	3.00	0.90	3.00
$N_1P_1V_1$	24.92	4.20	22.45	0.85	9.60	3.00	0.84	2.80
$N_2P_1V_1$	21.60	3.47	19.75	1.18	10.70	3.40	0.99	3.33
$N_3P_1V_1$	19.07	3.60	17.04	1.09	9.40	3.20	0.90	3.00
$N_0P_2V_1$	23.17	3.73	21.75	0.68	9.50	3.00	0.87	2.90
$N_1P_2V_1$	20.35	3.27	18.31	0.87	10.50	3.40	0.93	3.10
$N_2P_2V_1$	22.04	3.53	19.19	1.32	10.20	3.50	0.98	3.27
$N_3P_2V_1$	22.55	4.07	20.09	1.15	9.40	3.33	0.94	3.07
C.D. (P=0.05)	2.348	0.426	2.77	0.167	0.06	0.042	0.005	0.027
SE(m)	0.822	0.149	0.97	0.058	0.021	0.015	0.002	0.01
SE(d)	1.163	0.211	1.371	0.083	0.03	0.021	0.003	0.013
C.V.	5.991	6.967	7.88	10.898	0.423	0.865	0.396	0.605

Table 3: Correlation of different treatment combination for yield attributing traits of garlic cv. Gangajali

	Plant height	Leaf no.	Leaf length	Leaf breadth	Bulb weight	Bulb diameter	Yield plot^{-1}
Plant height	1	-0.108	0.924**	-0.075	-0.317	-0.142	-0.223
Leaf no.	-0.108	1	0.059	0.261	-0.149	-0.39	-0.057
Leaf length	0.924**	0.059	1	-0.08	-0.28	-0.141	-0.218
Leaf breadth	-0.075	0.261	-0.08	1	0.405*	0.401	0.648**
Bulb weight	-0.317	-0.149	-0.28	0.405*	1	0.660**	0.575**
Bulb diameter	-0.142	-0.39	-0.141	0.401	0.660**	1	0.693**
Yield plot^{-1}	-0.223	-0.057	-0.218	0.648**	0.575**	0.693**	1

Table 4: Correlation of different treatment combination for yield attributing traits of garlic cv. Katki

	Plant height	Leaf no.	Leaf length	Leaf breadth	Bulb weight	Bulb diameter	Yield plot^{-1}
Plant height	1	0.568**	0.940**	-0.042	-0.382	-0.475*	-0.443*
Leaf no.	0.568**	1	0.607**	0.151	-0.253	-0.038	-0.009
Leaf length	0.940**	0.607**	1	-0.131	-0.372	-0.506*	-0.445*
Leaf breadth	-0.042	0.151	-0.131	1	0.378	0.579**	0.647**
Bulb weight	-0.382	-0.253	-0.372	0.378	1	0.676**	0.585**
Bulb diameter	-0.475*	-0.038	-0.506*	0.579**	.676**	1	0.726**
Yield plot^{-1}	-0.443*	-0.009	-0.445*	0.647**	.585**	0.726**	1

Conclusion

The results revealed that all of the garlic phenological, growth and yield characteristics were significantly affected by the application of different levels of organic and inorganic nutrient combination. From different treatment combinations of NPV, it can be concluded that treatment $N_2P_1V_1$ (recommended dose of NPV 150:50:10) was found for increase bulb weight, bulb diameter in respect of higher bulb yield. Yield and yield related traits showed significant differences in response to the application of different levels of nitrogen and vermicompost. Character association studies revealed that leaf breadth, bulb weight and bulb diameter were significant and positive associated with bulb yield and therefore selection will be effective with these parameters.

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