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Productivity of Garlic Grown Under Different Tillage Condition and Standardization of Production Technology under Dry and Wet Land Conditions

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Abstract—*A series of experiment were carried out at the Alliums field laboratory, Horticulture Farm and laboratory of the BAU-Germplasm Centre, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, during the period from 2007-08 to 2012-13 and in the Spice Research Centre (SRC), Bogra during 2012-2013 to assess the control of bulbing in garlic through manipulation of different production systems as influenced by different germplasm, planting time, sources of nitrogen, application of fertilizers, plant spacing, planting system, seed clove size, mulch, tillage and irrigation. In 2007-08 growing season, the treatment combination of zero tillage with the 10 cm thickness of mulch produced the highest yield (9.92 t/ha).Moreover ,zero tillage condition showed the highest storage quality because it possessed the lowest values in case of weight loss (8.45%) ,insect infested bulbs (6.67%) as well as percent rotten bulbs (2.44%) even after 150 days of storage .In contrast , conventional tillage with no mulch and conventional tillage with 6cm mulch were found to have lower storage quality compared to the other treatment combinations. Zero tillage garlic showed remarkable variation. However differences were not significant between rice straw and water hyacinth mulch. It was also noticed that both the tillage conditions as well as mulches exerted profound effects on the yield and yield contributing parameters. Paddling and zero tillage garlic resulted higher yield compared to the conventional tillage. In 2009-10 growing season, the study was undertaken by the problem of late planted garlic in Bangladesh and similar tropical regions where production is only possible during the short cool winter period after which rapid increase in temperature as well as humidity adversely affect the growth. Experiments were carried out in order to develop suitable variety (ies) and production techniques to get high yield and to overcome the stated adverse situation. The results revealed that the plant height, number of leaves per plant, fresh and dry weight of bulb, length and diameter of bulb, total number of cloves, yield per plot and yield per hectare were significantly influenced by the treatment of different experiments under study. Results showed that among different germplasm, germplasm G_{19} was the best for yield and yield contributing characters. November 3 planting produced higher yield than early and late planted one. Garlic line G_{19} produced the highest yield in all the experiments studied under dry and wetland conditions. Ridge system gave the better performance in all the above mentioned parameters. Organic manure cowdung showed better effect on yield contributing characters and yield of garlic. Wider spacing reduced the yield per unit area and the closest spacing produced higher yield. Large size clove produced higher yield than small one, and the highest yield was recorded from the maximum dose of nitrogen (175 kg/ha). Potassium also showed good effect on yield, and the maximum yield was obtained from the maximum dose of potassium (200 kg/ha). Plants grown with water hyacinth mulch showed better performance in most of the yield contributing characters and yield than non-mulched one. Developed technology (planting time - 20 Oct. to 13 Nov.; Urea - 388.90 kg/ha; MP - 333.33 kg/ha; mulch - water hyacinth; Source of N - Cowdung; plant spacing - 20 cm × 10 cm; seed clove size -1.22g and planting system – Ridge) performed better on all the mentioned parameters studied than the recommendation of BARI technology (planting time - 1 to 7 Nov.; Urea - 217 kg/ha; MP - 267 kg/ha; mulch - Rice straw; Source of nitrogen - Urea; plant spacing - 20 cm × 15 cm; seed clove size - 1.00 g ; planting system - Flat).*

1. INTRODUCTION

The poor yield of garlic may be due to inadequate soil and water management practices in particular to soil water shortage in the soil profile. However, a considerable amount of fallow land can be brought under garlic cultivation through utilization of residual soil moisture plus supplemental irrigation. Unfortunately little work has been done in Bangladesh to test the feasibility of garlic production by conserving soil moisture through the management of tillage and mulch practices. From the previous experiment it was found that both tillage as well as mulches exerted profound effects on yield and yield contributing characters. The present investigation was carried out to determine the combined effect of mulches and tillage on garlic

2. MATERIALS AND METHODS

Expt 1. Productivity of garlic grown under different tillage conditions and mulches in presence of organic manure: This experiment was conducted at the Alliums field laboratory, Horticulture Farm and laboratory of the BAU-Germplasm Centre, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, during the period from 2007-08. The experiment was consisted of three tillage conditions; (i) Conventional or normal tillage (4 ploughings followed by laddering); ii) Puddling (2 ploughings followed by irrigation); iii) Zero tillage (without land preparation in the wet soil); and four mulches (i) no mulch ii) Rice straw; iii) Water hyacinth (*Eichorina* and iv) Sott leaf (*Curcuma amada*) mulch for garlic. The two factor experiment was laid out in the randomized complete block design with 3 replications with the following objectives are:i) to compare the production of garlic under different tillage conditions and ii) to identify the best mulches. The results were analyzed following the MATAT package program

Expt. 2 Comparison between developed technology and BARI recommended technology: In another experiment in the 2007-2008 growing season, a comparison of the developed of production technology for two registered varieties of garlic (BAU Garlic-1; BAU Garlic-2) with BARI recommended technology under dry land (conventional cultivation method) and wet land (zero tillage method) conditions was made at the same site of BAU, Mymensingh. Design,analysis and other practices were the same as Expt.1.

3. RESULTS AND DISCUSSION

From the experiment 1,The highest number of emergence (95.17 %) was obtained from the rice straw mulch. The plants grown with sotty leaf mulch gave the lowest emergence (87.72 %) per plot. On the other hand, the highest emerged plants (93.67 %) were recorded from the zero tillage conditions, whereas the lowest (90.67 %) was noted from the well tilth plot under dry land conditions. Again, significant interaction and combined effects were found due to the treatment combination of different mulches and tillage in respect of percent emergence. The maximum emergence (97.63 %) was obtained from the rice straw mulch + zero tillage followed by water hyacinth mulch + zero tillage (96.37 %), no mulch + puddling (96.10 %) and rice straw mulch + puddling (95.07 %). The minimum emergence (85.07 %) was obtained from the treatment combination of sotty leaf mulch + conventional tillage. The treatment rice straw mulch showed better performance than the control or sotty (*Curcuma amada*) leaf. The rice straw conserved more moisture in the soil compared to other mulch practices. The higher yield in the rice straw mulch might also be due to decreased sol temperature and diurnal temperature fluctuation too, and more efficient conservation of water, which favoured growth of crop. High soil temperature suppressed the rate of root elonagation and decreased root density in the surface layer of unmulched bare soil. The increased root density enhanced uptake of water and nutrients and ultimately increased plant height and yield of garlic. Furthermore, rice straw mulch prevented the weeds and ultimately plants grew without any competition. Similar pattern of results are reported by Halim (2002) amd Aliuddin (1986).

Different tillage also had significant influence on yield and yield contributing traots of garlic. The tallest plant (72.75 cm), maximum number of leaves/plant (8.05) at 90 DAP, length of the longest leaf (41.65 cm), fresh bulb weight (17.72 g), fresh leaf weight/plant (17.40 g), dry bulb weight (3.22 g), dry leaf weight/plant (2.57 g) and dry root weight/plant (0.20 g), yield per plot (2.08 kg) and per hectare (10.38 ton) was recorded from puddling method. On the other hand, the highest breadth of leaf (1.25 cm), bulb diameter (3.22 cm) and number of cloves per bulb (18.55) were observed from the zero tillage. No. significant differences were observed between puddling and zero tillage in respect of yield per hectare. The combined effect of mulches and tillage was significant for different growth attributes and bulb yield of garlic. The treatment combination zero tillage + rice straw mulch produced the highest yield (12.00 t/ha) while the lowest yield (6.12 t/ha) was obtained from the treatment combination zero tillage + no mulch. So, garlic cultivation under zero tillage covering either by rice straw or water hyacinth mulch was a very advantageous production system.

Table 1: Combined effect of different mulch materials and tillage on the yield and yield contributing characters of garlic

Treatment	Fresh weight(g) of			Dry weight(g) of			Bulb diameter (cm)	Cloves /bulb (No.)	Yield (kg/ plot)	Yield (t/ ha
	Leaves per plant	Bulb	Roots per plant	Leaves per plant	Bulb	Roots per plant				
$M_0 P_d$	16.20	15.73	0.61	2.39	2.87	0.19	2.97	16.67	1.89	9.47
M_0N_t	14.67	15.07	0.53	2.16	2.73	0.16	2.96	16.33	1.77	8.87
$M_0 Z_t$	11.67	10.73	0.47	1.72	1.78	0.13	2.39	11.27	1.22	6.12
M_1P_d	19.00	19.87	0.75	2.80	3.60	0.23	3.37	18.60	2.37	11.87
$M_1 N_t$	15.20	16.07	0.61	2.23	2.91	0.19	3.07	17.87	1.86	9.32
$M_1 Z_t$	19.20	20.93	0.83	2.83	4.15	0.25	3.77	22.20	2.40	12.00
$M_2 P_d$	17.80	19.07	0.69	2.63	3.46	0.22	3.09	19.73	2.24	11.17
$M_2 N_t$	16.33	16.27	0.58	2.40	2.90	0.19	3.15	17.93	1.94	9.68
$M_2 Z_t$	17.07	19.27	0.77	2.51	3.53	0.25	3.63	21.47	2.38	11.90

$M_3 P_d$	16.60	16.20	0.59	2.45	2.95	0.18	2.97	15.80	1.81	9.03
$M_3 N_t$	13.07	14.40	0.54	1.91	2.61	0.17	2.79	13.40	1.54	7.68
$M_3 Z_t$	16.87	17.13	0.61	2.48	3.09	0.18	3.09	19.27	1.98	9.87
LSD 5%	3.07	2.89	0.09	0.37	0.49	0.04	0.29	2.50	0.33	1.67
LSD 1%	4.17	3.93	0.13	0.51	0.66	0.05	0.40	3.40	0.45	2.27
Level of significance	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level

M_0 = No mulch
M_1 = Rice straw
M_2 = Water hyacinth and
M_3 = Sotty leaf mulch

P_d = Puddling
N_t = Normal or conventional tillage and
Z_t = Zero tillage

From Expt.2, Garlic line G_{19} resulted the best performance in respect of all the mentioned parameters. This maybe due to the genetic physiological characteristics and for adopted cultural practices. Developed technology resulted superior performance compared to recommended technology of BARI. This maybe due to November 3 plants received, low temperature immediately after planting helping plants growing more foliages which in return took part in enhanced photosynthetic activities leading to the production of more yields, cowdung significantly increased the yield as compared to urea, cowdung help the plant to establish easily in the field and easily uptake nutrient slowly at tender stage of the plant.High ratio of critical K_2O/N_2 in soil not only increases photosynthetic activities but also bulb growth leading to accelerated translocation of photosynthates from leaves of bulb (Fujise and Tsuno, 1967).Ridge system exhibited remarkable vegetative growth in garlic plants as stated earlier, hence it might have helped produce heavier bulb. Wider spacing gave the highest yield in individual plant but lower yield per hectare yield because of wider spacing accommodated less number of plant per unit area. With the increase in clove size, the yield of bulb per hectare increased. This is probably due to higher amount of initial reserves food material in the propagating unit. This ensures better plant growth which helps in maximum bulb yield .Hyacinth mulching kept soil in most favourable condition which resulted in maximum bulbing. Developed technology gave better results compared to recommended technology. This is might be due fact that developed technology accumulated favourable temperature ,soil moisture and supplied balanced nutrient which encouraged better vegetative growth and yield.

The garlic lines G_{19} gave maximum height of plant, number of leaves per plant, fresh and dry weight of leaves per plant, fresh and dry weight of bulb, length of bulb, total number of cloves per bulb, fresh and dry weight of roots per plant, yield per plot and yield per hectare than that of garlic line G_2. The yield of garlic was found to be influenced by different production technology with the developed technology, the yield of bulb per hectare increased. This was probably due to the higher amount of initial reserved food material in the garlic line G_{19}. In garlic line G_{19}, crop emerged rapidly and thereafter established quickly on its physiological system. The garlic line G_{19} ensured better plant growth with maximum height and leaves which in turn cumulatively yielded more photosynthates leading to enhanced production.

Table 2: Combined effect of BAU garlic varieties and production technology on the size of bulb, leaf, root and yield of garlic under dry land condition at harvest

Treatment combination	Fresh weight of bulb (g)	Dry weight of bulb (g)	Fresh weight of leaves (g)	Dry weight of leaves (g)	Length of bulb (cm)	Diameter of bulb (cm)	No. of cloves / bulb	Fresh weight of roots (g)	Dry weight of roots (g)	Yield / plot (kg)
$G_{19}T_1$	41.29	8.76	23.98	4.71	4.72	4.64	33.50	4.44	1.08	3.21
$G_{19}T_2$	39.11	6.43	19.85	2.97	4.44	4.49	31.40	2.84	0.89	2.89
G_2T_1	32.20	8.20	21.65	4.16	3.90	4.00	29.60	4.21	1.03	2.34
G_2T_2	29.50	5.89	16.61	2.36	3.10	3.50	26.40	2.63	0.73	2.13
LSD 5%	1.12	0.19	0.25	0.04	0.22	0.23	1.34	0.06	0.03	0.21
1%	1.56	0.25	0.34	0.05	0.30	0.31	1.82	0.09	0.04	0.28
Level of Significance	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability
T_1 = Developed technology, T_2 = Recommendation of BARI
V_1 = BAU garlic 1 (G_{19}) V_2 = BAU garlic 2 (G_2)
১ The size of a plot was 1.5m × 1m

Production technology has been shown to have a great influence on bulbing of garlic and can also act as a substitute for the requirement of proper environment for garlic production. The shallow rooted crops are more sensitive to water stress. Their roots do not have access to reserved underground soil water that deep-rooted crops have. Therefore, in garlic cultivation maintenance of upper soil level with required water maximizes growth rate and ensures all physiological activities leading to higher yield.

The results demonstrated that the growth of plants, development of bulb and yield were significantly better in the newly developed technology than the BARI recommended technology both under dry and wetland conditions. The garlic variety BAU Garlic-1 with the developed technology yielded

21.4 t/ha under the dry land condition, and 14.2 t/ha under wetland condition.s Whereas, the garlic variety BAU Garlic-2 with the developed technology yielded 17.9 t/ha under the dry land condition, and 12.1 t/ha under the wetland condition.

Table 3: Combined effect of BAU garlic varieties and production technology on the size of bulb, leaf, root and yield of garlic under wetland condition at harvest

Treatment combination	Fresh weight of bulb (g)	Dry weight of bulb (g)	Fresh weight of leaves (g)	Dry weight of leaves (g)	Length of bulb (cm)	Diameter of bulb (cm)	No. of cloves / bulb	Fresh weight of roots (g)	Dry weight of roots (g)	Yield / plot (kg)[1]
$G_{19}T_1$	36.30	7.61	24.95	5.509	4.44	4.23	28.30	4.84	1.18	2.69
$G_{19}T_2$	34.30	6.95	20.80	3.020	4.04	3.82	26.40	3.23	0.92	2.50
G_2T_1	28.20	5.91	22.60	4.230	3.40	3.20	24.80	4.61	1.09	2.09
G_2T_2	25.50	5.09	17.59	2.44	3.10	2.80	21.60	3.03	0.81	1.86
LSD 5%	1.49	0.11	0.43	0.05	0.14	0.19	1.11	0.03	0.03	0.05
1%	2.01	0.28	0.58	0.07	0.20	0.26	1.50	0.04	0.04	0.07
Level of Significance	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

T_1 = Developed technology T_2 = Recommendation of SRC

G_{19} = BAU Garlic-1 G_2 = BAU Garlic-2

1 The size of a plot was 1.5m × 1m

Now-a-days in the chalan beel (lan remain six months under deep water cultivating deep water rice) areas about 90% farmers are growing garlic following the zero tillage system. However, further research in this line is continuing in BAU sites as well as in the farmers field.

Under wetland condition, the cloves were planted on last week of November. The garlic cloves were planted in the muddy land without any tillage operation followed by covering with rice debri. Soil moisture was 65% - 71% during the experiment period. So, moisture available at root zone of the plant enhanced vegetative growth and ultimate higher yield. Water hyacinth mulch was used in the experimental plot as treatment. Hyacinth mulch prevented the weeds and ultimate plants grew without any competition. Shorter interval of irrigation, on the other hand, kept soil too moist for longer period resulting poor growth of roots and shoots leading to less yield. The garlic is a shallow rooted crop. The field where either irrigation or mulch was not applied crop could not perform well in respect of vegetative growth as well as yield.

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