

## Original Research Article

### Effect of Organic Sources and Fertilizer Levels on Physiological Response of Garlic by using Infrared Gas Analysis (IRGA) in Western Rajasthan.

#### Abstract

Maintenance of growth, development, and physiological processes in general is a key requirement for the survival of multicellular organisms such as plants and animals. The situation has aggravated due to the drastic and rapid changes in global climate. Nutrient management is the most important practice having huge impact on growth and productivity of the crops. It is very important to understand the physiological, biochemical, and ecological interventions related to these stresses for better management. Crop growth and yields are negatively affected by sub-optimal water supply and abnormal temperatures due to physical damages, physiological disruptions, and biochemical changes. A better understanding of garlic responses to organic and inorganic sources conducted two years field experiment was at Agricultural Research Farm, SKRAU, Bikaner during Rabi 2020-21 and 2021-22. The experiment comprising total 32 treatment combinations; eight sources of organics and four fertilizer levels. materials. Result indicated that maximum improvement in photosynthetic rate was recorded under the wool waste applied @ 20 t ha<sup>-1</sup> with 100% recommended dose of fertilizer.

Comment [Ap1]: Please stating in detail

**Keywords:** Wool waste, FYM, Groundnut husk, fertilizer and Photosynthetic rate

#### INTRODUCTION

Garlic (*Allium sativum* L.), a member of the family *Alliaceae*, is the premier bulbous crop which is consider in spices and vegetable section. In India, it is commonly known as Lahsun. The primary center of origin of garlic is Central Asia and Southern Europe and secondary center is Mediterranean region [17]. It has higher nutritive value than other bulb crops. It is used for

28 flavoring foods, preparing chutneys, pickles, curry powder, tomato ketchup etc. Its volatile oil  
29 has many sulphur containing compounds that are responsible for the strong odor, flavor/aroma,  
30 pungency.

31 Crops respond well to manure and fertilizer applications. However, continuous use of the  
32 heavy doses of fertilizers damages the natural ecology and adversely affects the nutrient  
33 recycling and the biological communities in soil which otherwise support the crop production  
34 [15]. Plant nutrients plays an important role in crop production and used various source of  
35 nutrients, they supplied various essential plant nutrients for proper growth and internal metabolic  
36 activities in plant body. Application of all essential nutrients through chemical fertilizers are  
37 known to have deleterious effect on soil fertility leading to unsustainable yields, while  
38 integration of chemical fertilizers with organic manures are able to maintain the good soil health,  
39 productivity and fertility status of soil [7].

40 Rate of plant growth and development is dependent upon the temperature surrounding the  
41 plant and each species has a specific temperature range represented by a minimum, maximum,  
42 and optimum. These values were summarized by [2,3] for a number of different species typical  
43 of grain and fruit production. The temperature response of different species has been evaluated  
44 by [10,11,12,13,14,15]. A recent IPCC report indicated, with medium confidence, that crop  
45 yields will experience 'severe and widespread impacts' if global warming exceeds 1.5 °C above  
46 pre-industrial levels, but that these impacts can be managed below this warming threshold [5].  
47 Atmospheric concentrations of carbon dioxide have been steadily rising, from approximately 315  
48 ppm (parts per million) in 1959 to a current atmospheric average of approximately 385 ppm [8].  
49 Current projections are or concentrations to continue to rise to as much as 500–1000 ppm by the  
50 year 2100 [6]. While a great deal of media and public attention has focused on the effects that  
51 such higher concentrations of CO<sub>2</sub> are likely to have on global climate, rising CO<sub>2</sub> concentrations  
52 are also likely to have profound direct effects on the growth, physiology, and chemistry of plants,  
53 independent of any effects on climate [18]. Water is required for processes such as germination,  
54 cell division and elongation for the promotion of plant growth in height and width and metabolic  
55 activities, such as the synthesis of organic compounds, photosynthesis, respiration and a number  
56 of other physiological and biochemical processes [16]. Hence a study was undertaken to assess

57 the effect of organic sources and fertilizer levels on physiological response of garlic in arid  
58 region of western Rajasthan.

## 59 MATERIAL AND METHODS

60 A two years field experiment was conducted at Agricultural Research Farm, SKRAU,  
61 Bikaner during Rabi 2020-21 and 2021-22. The experiment comprising total 32 treatment  
62 combinations; eight sources of organic materials (Control (M<sub>0</sub>), FYM @ 20 t ha<sup>-1</sup> (M<sub>1</sub>),  
63 Groundnut husk (GNH) @ 20 t ha<sup>-1</sup> (M<sub>2</sub>), Wool waste (WW) @ 20 t ha<sup>-1</sup> (M<sub>3</sub>), FYM @ 10 t ha<sup>-1</sup>  
64 + GNH @ 10 t ha<sup>-1</sup> (M<sub>4</sub>), WW @ 10 t ha<sup>-1</sup> + GNH @ 10 t ha<sup>-1</sup> (M<sub>5</sub>), WW @ 10 t ha<sup>-1</sup> + FYM @  
65 10 t ha<sup>-1</sup> (M<sub>6</sub>), WW @ 6.67 t ha<sup>-1</sup> + FYM @ 6.67 t ha<sup>-1</sup> + GNH @ 6.67 t ha<sup>-1</sup> (M<sub>7</sub>) and four  
66 fertilizer levels (Control (F<sub>0</sub>), 50% RDF (F<sub>1</sub>), 75% RDF (F<sub>2</sub>) and 100% RDF (F<sub>3</sub>) in split plot  
67 design with three replications. The RDF of garlic was 50 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 100 kg K<sub>2</sub>O was  
68 applied.

69 Ten plants were selected from each plot excluding the border row for taking observation.  
70 The observations were recorded on Infrared Gas Analyzer. Observations recorded different  
71 parameters in normal environment as well as stress environment. All the parameters were  
72 recorded by Infrared gas analysis (IRGA) model number CI-340. The CI-340 Ultra-Light  
73 Portable Photosynthesis System is an improved version of the first light weight, hand-held  
74 photosynthesis system in the world. Featuring a new design concept and compact solid-state  
75 structure, the entire system display, keypad, computer, data memory, CO<sub>2</sub>/H<sub>2</sub>O gas analyser,  
76 flow control system and battery is contained in a single, hand-held case. Principle of Infrared  
77 Gas Analysis is measures heteroatomic trace gases based on the absorption wavelength of  
78 infrared (IR) light as it passes through an air sample. Parameters can be recorded by Infrared gas  
79 analysis (IRGA) model number CI-340 show in Table 1. Water use efficiency (WUE) is the ratio  
80 of net photosynthesis rate (umol/m<sup>2</sup>/s) to transpiration rate (mmol/m<sup>2</sup>/s). Carboxylation  
81 efficiency is the ratio of net photosynthesis rate (umol/m<sup>2</sup>/s) to Internal CO<sub>2</sub> concentration (ppm)  
82

**Comment [Ap2]:** What are the environmental conditions of the research location and the weather conditions when the research was conducted so that the resulting findings may be applied in areas with similar environmental conditions

**Comment [Ap3]:** please state the ones that are generally known

**Comment [Ap4]:** idem

**Comment [Ap5]:** What is the size of 1 experimental unit and what is the planting distance, how old are the plants used as research material

83 **Table 1: List of physiological data recorded by Infrared gas analysis (IRGA) model**  
 84 **number CI-340.**

S.No.	Denoted by	Abbreviation	Unit
1.	Internal T	Internal temperature for the instrument	deg C
2.	Pressure	Atmospheric pressure	kPa
3.	Tair	Air temperature	deg C
4.	CO2in	Inlet CO <sub>2</sub>	ppm
5.	H2Oin	Inlet water pressure	kPa
6.	W	Mass flow rate	mol/m <sup>2</sup> /s
7.	E	Transpiration rate	mmol/m <sup>2</sup> /s
8.	RHin	inlet relative humidity	%
9.	int CO <sub>2</sub>	Internal CO <sub>2</sub> concentration	ppm
10.	Flow	Flow rate	l/min
11.	PAR	Photosynthesis Active Radiation	umol/m <sup>2</sup> /s
12.	Tleaf	Leaf temp.	deg C
13.	CO2out	Outlet CO <sub>2</sub>	ppm
14.	H2Oout	Outlet water pressure	kPa
15.	Pn	Net photosynthesis rate	umol/m <sup>2</sup> /s
16.	C	Stomatal conductance rate	mmol/m <sup>2</sup> /s
17.	RHout	Outlet relative humidity	kPa
18.	VPD	Vapour-pressure deficit	kPa
19.	fluorescence	fluorescence	
20.	Month	Current month	
21.	H, min and s	Time experiments conducted	
22.	Date	Current date	
23.	Year	Current year	

85

86

87 **RESULTAND DISCUSSION**

88 The present study is conducted to understand the physiological reaction of organic  
89 sources and fertilizer levels 32 treatment combinations. Here we discuss effects of these  
90 treatment on garlic crop on the basis on net photosynthesis, transpiration rate, Photosynthesis  
91 active radiation, leaf temperature, air temperature, inlet CO<sub>2</sub>, vapor pressure Deficit, outlet CO<sub>2</sub>  
92 inlet relative humidity, outlet relative humidity, outlet water pressure and inlet relative humidity.  
93 Table 2 indicated that on the pooled basis maximum photosynthetic rate was recorded under the  
94 wool waste applied @ 20 t ha<sup>-1</sup> with 100% recommended dose of fertilizer (M<sub>3</sub>F<sub>3</sub>). It might due  
95 to photosynthesis is the formation of carbohydrates from CO<sub>2</sub> and a source of hydrogen (as  
96 water) in the chlorophyll containing tissues of plants exposed to light. The rate at which  
97 photosynthesis occurs is determined by measuring the rate at which a known leaf area assimilates  
98 the CO<sub>2</sub> concentration in a given time. Temperature, carbon dioxide concentration and light  
99 intensity can affect the rate of photosynthesis. and this may be owing to increased supply of  
100 multi-nutrients, plant growth regulators and beneficial microflora released from wool waste Its  
101 addition to soil creates most favourable conditions and improved with respect to physico-  
102 chemical and biological properties of the soil which promoted plant growth by ensuring higher  
103 number of greener leaves with increased photosynthesis as a result of increased metabolism of  
104 the plant ultimately increased vegetative parameters as above.

105 Hence now we can say that the organic sources with fertilizer levels increased plant  
106 photosynthetic rate as well as physiological response. Similar result reported by [4,1,9].

**Comment [Ap6]:** The data produced from this research is quite complete but the author does not carry out analysis and discussion of the observed factors but goes straight to conclusions

**Comment [Ap7]:** lines 88 to 92 are part of the introduction

**Comment [Ap8]:** It is necessary to discuss the possibility that increasing the dose will still have a positive effect on plant growth performance

**Comment [Ap9]:** Line 96 to 104 is a statement that has been agreed upon by experts. Therefore, it should be related to the type of treatment given

**Comment [Ap10]:** Again... it is general statement

Treatment	T <sub>air</sub>	T <sub>leaf</sub>	CO <sub>2</sub> <sub>in</sub>	CO <sub>2</sub> <sub>out</sub>	H <sub>2</sub> O <sub>in</sub>	H <sub>2</sub> O <sub>out</sub>	RH <sub>in</sub>	RH <sub>out</sub>	VP <sub>D</sub>	E	PAR	Pn	C	int_CO <sub>2</sub>	WUE	Ce
M <sub>0</sub> F <sub>0</sub>	24.00	23.60	1280.20	1270.70	1.69	2.22	56.40	74.00	0.71	1.76	263.60	3.07	269.03	1260.40	1.74	0.0024
M <sub>0</sub> F <sub>1</sub>	21.40	21.00	1281.90	1266.10	1.37	1.91	53.50	74.70	0.58	1.81	169.60	5.17	344.41	1255.40	2.86	0.0041
M <sub>0</sub> F <sub>2</sub>	21.00	21.50	1283.10	1263.80	1.35	1.89	54.30	75.70	0.69	1.80	338.00	6.34	283.75	1244.30	3.52	0.0051
M <sub>0</sub> F <sub>3</sub>	23.70	24.50	1340.20	1320.10	1.47	2.12	49.80	71.80	0.98	2.15	367.90	6.54	235.43	1292.70	3.04	0.0051
M <sub>1</sub> F <sub>0</sub>	23.20	23.70	1266.30	1220.30	1.49	2.10	52.40	73.80	0.84	2.02	272.40	15.01	258.70	1166.30	7.43	0.0129
M <sub>1</sub> F <sub>1</sub>	23.90	23.60	1302.00	1211.20	1.65	2.38	55.60	79.90	0.55	2.42	113.30	29.67	506.52	1194.10	12.26	0.0248
M <sub>1</sub> F <sub>2</sub>	24.60	24.40	1253.50	1148.20	1.52	2.54	48.80	81.70	0.54	3.42	250.40	34.28	787.13	1167.40	10.02	0.0294
M <sub>1</sub> F <sub>3</sub>	23.30	22.50	1379.10	1255.20	1.58	2.18	55.00	75.90	0.56	2.00	191.20	40.42	401.54	1198.60	20.21	0.0337
M <sub>2</sub> F <sub>0</sub>	22.40	22.20	1310.20	1289.40	1.39	2.02	51.10	74.30	0.67	2.10	209.40	6.80	344.83	1275.40	3.24	0.0053
M <sub>2</sub> F <sub>1</sub>	24.80	24.50	1439.00	1086.40	1.69	1.93	53.80	61.60	1.15	0.09	209.70	12.76	7.78	1100.00	141.78	0.0116
M <sub>2</sub> F <sub>2</sub>	23.20	23.70	1266.30	1220.30	1.49	2.10	52.40	73.80	0.84	2.02	272.40	15.01	258.70	1166.30	7.43	0.0129
M <sub>2</sub> F <sub>3</sub>	23.90	23.70	1259.90	1208.10	1.47	2.22	49.40	74.70	0.73	2.49	217.70	16.84	379.43	1180.80	6.76	0.0143
M <sub>3</sub> F <sub>0</sub>	20.20	20.60	1336.60	1166.90	1.34	1.98	56.30	83.00	0.46	2.13	253.60	55.79	539.13	1144.20	26.19	0.0488
M <sub>3</sub> F <sub>1</sub>	25.00	25.10	1345.40	1155.90	1.48	2.44	46.60	76.90	0.75	3.19	222.80	61.24	484.36	1113.80	19.20	0.0550
M <sub>3</sub> F <sub>2</sub>	23.30	21.70	1593.10	1278.10	1.44	2.31	50.10	80.30	0.30	2.89	166.60	102.71	1353.00	1422.40	35.54	0.0722
M <sub>3</sub> F <sub>3</sub>	25.20	26.30	1655.80	1275.60	1.40	2.24	43.60	69.70	1.19	2.77	219.80	122.43	250.34	814.60	44.20	0.1503
M <sub>4</sub> F <sub>0</sub>	19.30	18.00	1313.00	1276.20	1.30	1.58	58.00	70.50	0.49	0.95	220.90	12.20	205.20	1212.00	12.84	0.0101
M <sub>4</sub> F <sub>1</sub>	23.10	22.70	1336.30	1247.60	1.44	2.05	50.70	72.30	0.72	2.05	231.40	29.07	312.04	1173.30	14.18	0.0248
M <sub>4</sub> F <sub>2</sub>	23.70	22.90	1255.10	1154.30	1.42	1.98	48.40	67.50	0.82	1.87	281.10	32.92	244.15	1023.60	17.60	0.0322
M <sub>4</sub> F <sub>3</sub>	23.40	23.20	1403.60	1281.20	1.36	2.06	47.00	70.90	0.81	2.32	299.80	39.92	312.85	1180.20	17.28	0.0332

**Comment [Ap11]:** To show the validity of research results, it should at least be equipped with a standard deviation

			0	0						1	0					8
<b>M<sub>5</sub>F<sub>0</sub></b>	24.70	24.80	1263.0 0	1170.9 0	1.37	2.14	43.80	68.40	1.00	2.5 4	230.3 0	29.73	275.07	1075.80	11.70	0.027 6
<b>M<sub>5</sub>F<sub>1</sub></b>	22.80	22.80	1326.6 0	1220.2 0	1.36	2.05	48.50	73.40	0.74	2.3 2	248.1 0	34.82	348.84	1150.20	15.01	0.030 3
<b>M<sub>5</sub>F<sub>2</sub></b>	25.10	25.30	1386.5 0	1254.1 0	1.46	2.56	45.60	80.10	0.67	3.6 5	171.3 0	42.67	646.49	1260.40	11.69	0.033 9
<b>M<sub>5</sub>F<sub>3</sub></b>	21.90	21.90	1384.1 0	1231.7 0	1.41	1.98	53.50	75.40	0.66	1.9 3	225.2 0	50.17	320.25	1109.30	25.99	0.045 2
<b>M<sub>6</sub>F<sub>0</sub></b>	23.80	23.30	1348.1 0	1187.4 0	1.71	2.38	58.00	80.80	0.48	2.2 4	76.00	52.29	542.42	1168.70	23.34	0.044 7
<b>M<sub>6</sub>F<sub>1</sub></b>	22.50	22.80	1576.6 0	1390.2 0	1.46	2.05	53.30	74.90	0.74	1.9 7	202.5 0	60.81	289.84	1211.70	30.87	0.050 2
<b>M<sub>6</sub>F<sub>2</sub></b>	25.20	24.80	1498.2 0	1308.1 0	1.35	2.36	42.00	73.20	0.77	3.3 3	139.0 0	61.45	495.33	1270.20	18.45	0.048 4
<b>M<sub>6</sub>F<sub>3</sub></b>	24.70	24.80	1472.9 0	1127.4 0	1.42	2.44	45.30	78.00	0.70	3.4 5	212.1 0	113.9 5	580.26	1104.00	33.03	0.103 2
<b>M<sub>7</sub>F<sub>0</sub></b>	18.00	18.60	1297.4 0	1216.0 0	1.22	1.21	58.80	58.60	0.94	1.8 5	249.0 0	27.21	380.00	1200.00	14.71	0.022 7
<b>M<sub>7</sub>F<sub>1</sub></b>	25.20	25.80	1243.3 0	1141.6 0	1.40	2.46	43.60	76.40	0.88	3.5 0	301.4 0	32.96	450.83	1110.50	9.42	0.029 7
<b>M<sub>7</sub>F<sub>2</sub></b>	24.60	24.90	1249.0 0	1129.6 0	1.32	2.55	42.70	82.10	0.61	4.0 8	274.8 0	38.87	837.36	1156.10	9.53	0.033 6
<b>M<sub>7</sub>F<sub>3</sub></b>	23.60	22.90	1694.6 0	1535.6 0	1.42	2.25	48.50	77.10	0.55	2.7 8	242.1 0	51.72	600.08	1531.90	18.60	0.033 8

**Table 2. Physiological parameters of garlic respond to organic sources with fertilizer levels**

**Comment [Ap12]:** Observations are only limited to the physiological parameters of the plant, it would be better to be completed with production data so that the best treatment can really be recommended, especially the one with the lowest cost and statistically the best production

## REFERENCES

1. Górecki, R.S. & Górecki, M.T. (2010). Utilization of waste wool as substrate amendment in pot cultivation of tomato, sweet pepper, and eggplant. *Polish Journal of Environmental Studies*, **19**(5): 1083-1087.
2. Hatfield, J. L., Boot, K. J., & Kimball, B. A. (2008). The effects of climate change on agriculture, land resources, water resources, and biodiversity. *Synthesis and Assessment Product*, 4.
3. Hatfield, J. L., Boote, K. J., Kimball, B. A., Ziska, L. H., Izaurralde, R. C., Ort, D., ... & Wolfe, D. (2011) Climate impacts on agriculture: implications for crop production. *Agronomy journal*, **103**(2), 351-370.
4. Indira, P., Lenin, M. & Mycin, T.R. (2010). Efficacy of groundnut haulm compost on the growth and yield of blackgram (*Vigna mungo* L.) var. Vamban 1. *Current Botany*, **1**(1): 1-3.
5. IPCC. 2018. Summary for policymakers. In: Masson- Delmotte, V., Zhai, P, Pörtner HO, et al. , eds. Global warming of 1.5 °C. Geneva, Switzerland: IPCC.
6. IPCC. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
7. Jeyabal, A., Palaniappan, S.P. & Chelliah, S. (2000). Effect of integrated nutrient management techniques on yield attributes and yield of sunflower (*Helianthus annuus*). *Indian Journal of Agronomy*, **45**(2): 384-388.
8. Keeling, C. D., & Whorf, T. P. (1994). Atmospheric CO<sub>2</sub> records from sites in the SIO air sampling network. *Trends*, **93**, 16-26.
9. Khandelwal, A.K. (2021) Efficacy of sheep based organic waste for improving soil health and productivity of Tomato (*Solanum lycopersicum* L.) under shade net house. *M.Sc. thesis*, S K Rajasthan Agricultural University, Bikaner.
10. Prasad, P. V. V., Boote, K. J., Allen Jr, L. H., Sheehy, J. E., & Thomas, J. M. G. (2006). Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress. *Field crops research*, **95**(2-3), 398-411.
11. Prasad, P. V. V., Craufurd, P. Q., Kakani, V. G., Wheeler, T. R., & Boote, K. J. (2001). Influence of high temperature during pre-and post-anthesis stages of floral development on fruit-set and pollen germination in peanut. *Functional Plant Biology*, **28**(3), 233-240.

12. Prasad, P. V., Boote, K. J., & Allen Jr, L. H. (2006). Adverse high temperature effects on pollen viability, seed-set, seed yield and harvest index of grain-sorghum [*Sorghum bicolor* (L.) Moench] are more severe at elevated carbon dioxide due to higher tissue temperatures. *Agricultural and forest meteorology*, **139**(3-4), 237-251.
13. Prasad, P. V., Boote, K. J., Allen Jr, L. H., & Thomas, J. M. (2002). Effects of elevated temperature and carbon dioxide on seed- set and yield of kidney bean (*Phaseolus vulgaris* L.). *Global Change Biology*, **8**(8), 710-721.
14. Prasad, P. V., Pisipati, S. R., Ristic, Z., Bukovnik, U. R. S. K. A., & Fritz, A. K. (2008). Impact of nighttime temperature on physiology and growth of spring wheat. *Crop science*, **48**(6), 2372-2380.
15. Prasad, P.H., Mandal, A.R., Sarkar, A., Thapa, U. & Maity, T.K., (2009). Effect of bio-fertilizers and nitrogen on growth and yield attributes of bitter gourd (*Momordica charantia* L.); *International Conference on Horticulture*, pp. 738-739.
16. Taiz, L., & Zeiger, E. (2006). *Plant Physiology* Sinauer Associates. Inc., Sunderland, MA.
17. Thompson, C.H. & Kelley, C.W. (1957). *Vegetable Crops*, Mc Graw Hill Book Co. Inc., New Delhi, 502.
18. Ziska, L. H. (2008). Rising atmospheric carbon dioxide and plant biology: the overlooked paradigm. *DNA and Cell Biology*, **27**(4), 165-172.