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Effect of Levels of Inorganic Fertilizers, Organic Manure and Bio-Fertilizers on Plant Growth Attributes of Onion (*Allium cepa* L.) cv. N-53 under Hot Arid Region of Western Rajasthan, India

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A B S T R A C T

The field experiment was conducted to study the "Effect of levels of FYM, fertilizers and biofertilizers on growth attributes of onion (*Allium cepa* L.) cv. N-53" in loamy sand soils of the Horticulture farm, S.K.R.A.U. College of Agriculture, Bikaner during *rabi* 2015-16 and 2016-17. The experiment comprising of 27 treatment combinations and replicated three times, was laid out in RBD with three fertility levels (0, 50 and 100% of recommended dose of NPK), three treatments of organic manure (control, FYM @ 20 t ha^{-1} and FYM @ 10 t ha^{-1}) and three bio-fertilizers (No inoculation, PSB inoculation and Azospirillum inoculation) were applied in the plots. The results of the study have clearly shown that application of inorganic fertilizers @ 100% RDF significantly increased all the growth parameters (Plant height, number of leaves, chlorophyll content in leaves and, fresh and dry weight of leaves) similarly followed by FYM @ 20 t ha^{-1} over the other treatments in the respective groups. Moreover, Application of *Azospirillum* treatment was also found significantly in all the growth attributes of onion bulbs over the control but is was statistically at par with PSB. Further it may be concluded that application of 100% RD of NPK + 20 t ha^{-1} FYM is worth recommendable for farmers of arid region to make better growth and development of onion in nutrient deficient soil of arid region.

Introduction

Onion (*Allium cepa* L.) is bulb vegetable crop grown in Rabi season and used in daily diet of people in the whole world. It becomes a major cash crop with higher market demand and price due to its culinary, dietary and medicinal values (Anonymous, 2003). India is the second largest producer of onion in the world, next to China, accounting for 22.18 % of the world area and 18.78 % of the world production. In India, onion is being grown in an area of 1.29 mha with production of 21.71 MT and the productivity is 16.83 t ha^{-1} (Anonymous, 2016). Even after restrictions, onion earns foreign exchange more than Rs. 3170 crores annually, which is about 55% of total fresh vegetables, and 36% of total vegetables and fruits (Anonymous, 2014). The main onion growing states in our country are

Maharashtra, Madhya Pradesh, Gujarat, Karnataka, Rajasthan, Tamil Nadu, Andhra Pradesh, Uttar Pradesh and Orissa. In Rajasthan, it is grown in an area of 62.56 thousand hectares with the production of 767.50 thousand MT and productivity of 12.26 MT ha^{-1} (Anonymous, 2016). Coarse textured soils of Rajasthan, having low organic carbon, low CEC and high permeability are inherently poor in nutrient retention. Applied nutrients are subjected to losses through leaching and volatilization resulting in economic loss to farmers.

Intensive and modern cultivation and, excess use of chemical fertilizers resulted in ill health of soil and unstable yield of crops as well as threat to environment also. But in recent years the usage of chemical fertilizers indiscriminately in an unbalanced manner has been shown to result in several problems like loss of fertility, soil health and multiple nutrient deficiencies and loss of microbial activities etc, which ultimately resulting in reduced crop productivity and quality (Singh *et al.*, 2017). The balanced fertilization has to be made for different crops based on soil test reports for attaining maximum yield and profit. There is meager information on the balanced use of chemical fertilizers along with FYM and biofertilizers for onion crop grown in Rajasthan. So in last few years, a greater concern regarding use of biofertilizers and organic source as alternative to chemical fertilization has been derived to reduce the high cost that inorganic fertilizers represent in agricultural production (Bharadwaj *et al.*, 1994).

Now a days there is a need to devise alternate ways to collect, process, compost, utilize organic manure as well as bio-fertilizers like *Azotobacter, Azospirillum, Acetobacter, Rhizobium, Azolla*, Blue green algae and Phosphate solubilizing bacteria enrich fertility status of the soil. The chemical fertilizers like N, P and K have played significant role on increasing yield and quality of plants in earlier. With this background of investigations, an attempt has been made to investigate the effect of levels of FYM, fertilizers and bio-fertilizers on growth, yield and quality of onion (*Allium cepa* L.) cv. N-53

Materials and Methods

The experiment was laid out at College Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner, during *"Rabi"* season of 2015-16 and 2016-17. Geographically, experimental site is situated 10 km away from Bikaner city on Sri Ganganagar road at an altitude of 234.70 meters above mean sea level and latitude of 28^0 01' N and longitude of 73^0 22' E. According to "Agro ecological region map" brought by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Bikaner falls under Agro ecological region No.2 (M_9E_1) under arid ecosystem (Hot Arid Eco-region with desert and saline soils), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity, hot and arid climate and annual precipitation is less than 300 mm, annual PET ranges between 1500 to 2000 mm. According to NARP, Bikaner falls in Agro-climatic zone I c, which is known as Hyper Arid Partially Irrigated North Western Plain zone.

The experiment comprising of 27 treatment combinations and replicated three times, was laid out in RBD with three fertility levels (0, 50 and 100% of recommended dose of NPK), three treatments of organic manure (control, FYM @ 10 t ha^{-1} and FYM @ 20 t ha^{-1}) and three bio-fertilizers (No inoculation, PSB inoculation and *Azospirillum* inoculation) were applied in the plots. The treatments of manure, chemical fertilizers and bio-fertilizers were applied as per treatment in respective plot. FYM were applied prior to 15 days of

transplanting of Onion. PSB and *Azotobactor* bio-fertilizer was applied at the time of transplanting. Nutrient like nitrogen, phosphorus and potassium were applied through urea, single super phosphate and muriate of potash, respectively as per experimental plan. 1/3 dose of N and K with full dose of P as a basal dose and remaining dose of N and K in two splits with irrigation at 30 and 60 days of transplanting respectively. The onion variety used in the experiment was "N-53". 45 days old seedlings of uniform growth were transplanted in evening hour at a spacing of 15x10 cm in flat beds. The gross plot size was 1.8 m x 1.8 m^2. The fertilizer applications were done as NPK @100:50:100kg ha^{-1} and Bio-fertilizers @ 1kg per 15 liter of water seedlings treatment. The recommended plant protection measures were taken as and when required.

Observations of growth parameters of onion plant like Plant height (cm), Number of leaves per plant, Fresh and dry weight of leaves (g) was recorded at 30, 60 and 90 days after transplanting whereas, chlorophyll content (mg/g^1) observed 60 DAT. For observation of plant ten-ten plants per plot were selected at random for the purpose in each observation at different stages of plant growth as mentioned earlier and after that the average value was calculated.

Results and Discussion

Plant growth attributes

Effect of inorganic fertilizers

The results of the study (Table 1, 2, 3 and 4) are clearly indicated that plant height, number of leaves per plant, chlorophyll content in leaves and fresh and dry of weight of leaves increased significantly by applying of 100 % RDF over the control and 50% RDF. It suggests that the application of increasing levels of fertility may be attributed to better nutrient uptake by the root zone owing to better development of nutritional environment nearby rhizosphere. It also plays an important role in plant metabolism by virtue of being an essential compound like amino acids, protein, nucleic acids, enzymes, coenzymes and alkaloids (Yadav, 2000, Mahala, 2015 and Meena, 2016). Similar to nitrogen, phosphorus is also an essential nutrient for plants and required in large quantity for proper plant growth and development. Plant derives their internal energy from P-containing compounds, mainly adenosine diphosphate (ADP) and adenosine triphosphate (ATP). This means that inadequate P supply will result in a decreased synthesis of RNA which ultimately hampers the plant growth and development.

Phosphorus deficient plants, therefore, are stunted with a limited root system and thin stem (Patel *et.al,* 1990 and Kumar, 2004). Potassium is an important for developing strength to the plants and built resistant to the plants against biotic and abiotic stresses. It is well known established fact the K also improve the quality yield of produce. Therefore, potassium fertilization improved overall crop growth in terms of plant height, number of leaves per plant, chlorophyll content in leaves and fresh and dry weight of leaves (Yadav *et al.,* 2008; Choudhary *et al.,* 2013; Sharma, 2014; Assefa *et al.,* 2015).

Effect of organic manure

The plant height, number of leaves per plant, chlorophyll content in leaves and, fresh and dry weight of leaves were significantly increased with application of FYM @ 20 t ha^{-1} and FYM @ 10 t ha^{-1}, respectively over control (Table 1, 2, 3 and 4). The positive influences on growth parameters are associated with the release of macro and micro nutrients during the course of microbial decomposition (Singh and Ram, 1982).

Table.1 Effect of inorganic fertilizers, organic manure and bio-fertilizers on plant height at 30, 60 and 90 DAT

Treatments	Plant height (cm)								
Inorganic fertilizers	30 DAT			60 DAT			90 DAT		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
F_0 (0% RD of NPK)	22.25	21.92	22.09	35.95	35.58	35.77	43.04	42.69	42.87
F_1 (50% RD of NPK)	29.33	28.71	29.02	43.76	43.08	43.42	50.46	49.81	50.14
F_2 (100% RD of NPK)	33.60	32.91	33.26	48.48	47.72	48.10	54.94	54.22	54.58
SEm±	0.43	0.42	0.30	0.47	0.46	0.33	0.45	0.44	0.31
CD (P=0.05)	1.21	1.18	0.84	1.34	1.30	0.92	1.27	1.24	0.88
Organic manure									
M_0 (Control)	25.23	25.00	25.12	39.24	38.99	39.11	46.16	45.93	46.05
M_1 (FYM 10 t ha^{-1})	28.86	28.54	28.70	43.25	42.90	43.07	49.97	49.64	49.81
M_2 (FYM 20 t ha^{-1})	31.09	29.99	30.54	45.71	44.50	45.10	52.31	51.16	51.74
SEm±	0.43	0.42	0.30	0.47	0.46	0.33	0.45	0.44	0.31
CD (P=0.05)	1.21	1.18	0.84	1.34	1.30	0.92	1.27	1.24	0.88
Bio-fertilizers									
B_0 (No-inoculation)	27.40	27.27	27.33	41.63	41.65	41.64	48.44	48.31	48.37
B_1 (PSB inoculation)	28.70	27.77	28.23	43.07	42.04	42.55	49.80	48.83	49.32
B_2 (*Azospirillum* inoculation)	29.08	28.48	28.78	43.49	42.99	43.24	50.21	49.59	49.90
SEm±	0.43	0.42	0.30	0.47	0.46	0.33	0.45	0.44	0.31
CD (P=0.05)	1.21	1.18	0.84	1.34	1.30	0.92	1.27	1.24	0.88

Table.2 Effect of inorganic fertilizers, organic manure and bio-fertilizers on number of leaves per plant and chlorophyll content in leaves at 60 DAT

Treatment	Number of leaves/plant			Chlorophyll (mg g^{-1})		
Inorganic fertilizers	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
F_0 (0% RD of NPK)	5.84	5.11	5.47	0.0643	0.0563	0.0603
F_1 (50% RD of NPK)	6.65	5.95	6.30	0.0695	0.0615	0.0655
F_2 (100% RD of NPK)	6.96	6.26	6.61	0.0707	0.0627	0.0667
SEm±	0.05	0.05	0.03	0.0006	0.0006	0.0005
CD (P=0.05)	0.14	0.14	0.10	0.0018	0.0018	0.0013
Organic manure						
M_0 (Control)	5.61	4.89	5.25	0.0629	0.0549	0.0589
M_1 (FYM 10 t ha^{-1})	6.73	6.02	6.37	0.0701	0.0621	0.0661
M_2 (FYM 20 t ha^{-1})	7.12	6.42	6.77	0.0715	0.0635	0.0675
SEm±	0.05	0.05	0.03	0.0006	0.0006	0.0005
CD (P=0.05)	0.14	0.14	0.10	0.0018	0.0018	0.0013
Bio-fertilizers						
B_0 (No-inoculation)	6.40	5.68	6.04	0.0660	0.0580	0.0620
B_1(PSB inoculation)	6.49	5.79	6.14	0.0688	0.0608	0.0648
B_2(*Azospirillum* inoculation)	6.56	5.86	6.21	0.0697	0.0617	0.0657
SEm±	0.05	0.05	0.03	0.0006	0.0006	0.0005
CD (P=0.05)	0.14	0.14	0.10	0.0018	0.0018	0.0013

Table.3 Effect of inorganic fertilizers, organic manure and bio-fertilizers on fresh weight of leaves per plant at 30, 60 and 90 DAT

Treatments	Fresh weight of leaves per plant (g)								
	30 DAT			60 DAT			90 DAT		
Inorganic fertilizers	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
F_0 (0% RD of NPK)	4.790	4.706	4.748	10.295	9.962	10.128	20.995	20.662	20.828
F_1 (50% RD of NPK)	6.558	6.403	6.480	17.367	16.748	17.058	28.067	27.448	27.758
F_2 (100% RD of NPK)	7.625	7.454	7.540	21.638	20.953	21.295	32.338	31.653	31.995
SEm±	0.107	0.104	0.075	0.427	0.416	0.298	0.427	0.416	0.298
CD (P=0.05)	0.303	0.295	0.209	1.213	1.180	0.836	1.213	1.180	0.836
Organic manure									
M_0 (Control)	5.533	5.477	5.505	13.269	13.045	13.157	23.969	23.745	23.857
M_1 (FYM 10 t ha^{-1})	6.441	6.362	6.402	16.900	16.584	16.742	27.600	27.284	27.442
M_2 (FYM 20 t ha^{-1})	6.999	6.724	6.862	19.131	18.034	18.582	29.831	28.734	29.282
SEm±	0.107	0.104	0.075	0.427	0.416	0.298	0.427	0.416	0.298
CD (P=0.05)	0.303	0.295	0.209	1.213	1.180	0.836	1.213	1.180	0.836
Bio-fertilizers									
B_0 (No-inoculation)	6.076	6.049	6.062	15.438	15.332	15.332	26.138	26.033	26.085
B_1(PSB inoculation)	6.400	6.168	6.284	16.738	15.810	16.274	27.438	26.510	26.974
B_2 (*Azospirillum* inoculation)	6.497	6.347	6.422	17.124	16.519	16.821	27.824	27.220	27.522
SEm±	0.107	0.104	0.075	0.427	0.416	0.298	0.427	0.416	0.298
CD (P=0.05)	0.303	0.295	0.209	1.213	1.118	0.836	1.213	1.180	0.836

Table.4 Effect of inorganic fertilizers, organic manure and bio-fertilizers on dry weight of leaves per plant at 30, 60 and 90 DAT

Treatments	Dry weight of leaves per plant (g)								
	30 DAT			60 DAT			90 DAT		
Inorganic fertilizers	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
F_0 (0% RD of NPK)	0.414	0.406	0.410	1.106	1.073	1.090	2.633	2.596	2.614
F_1 (50% RD of NPK)	0.591	0.575	0.583	1.814	1.752	1.783	3.419	3.350	3.384
F_2 (100% RD of NPK)	0.698	0.680	0.689	2.241	2.172	2.207	3.893	3.817	3.855
SEm±	0.011	0.010	0.007	0.043	0.042	0.030	0.047	0.046	0.033
CD (P=0.05)	0.030	0.029	0.021	0.121	0.118	0.084	0.135	0.131	0.093
Organic manure									
M_0 (Control)	0.488	0.483	0.486	1.404	1.381	1.393	2.963	2.938	2.951
M_1 (FYM 10 t ha^{-1})	0.579	0.571	0.575	1.767	1.735	1.751	3.367	3.332	3.349
M_2 (FYM 20 t ha^{-1})	0.635	0.607	0.621	1.990	1.880	1.935	3.615	3.493	3.554
SEm±	0.011	0.010	0.007	0.043	0.042	0.030	0.047	0.046	0.033
CD (P=0.05)	0.030	0.029	0.021	0.121	0.118	0.084	0.135	0.131	0.093
Bio-fertilizers									
B_0 (No-inoculation)	0.543	0.538	0.540	1.621	1.608	1.614	3.204	3.189	3.196
B_1(PSB inoculation)	0.575	0.552	0.563	1.751	1.658	1.704	3.349	3.246	3.297
B_2 (*Azospirillum* inoculation)	0.585	0.571	0.578	1.789	1.731	1.760	3.392	3.327	3.359
SEm±	0.011	0.010	0.007	0.043	0.042	0.030	0.047	0.046	0.033
CD (P=0.05)	0.030	0.029	0.021	0.121	0.118	0.084	0.135	0.131	0.093

The improvement in plant height, number of leaves per plant, chlorophyll content in leaves and, fresh and dry of weight of leaves might be due to better moisture holding capacity and availability of major and micro nutrients due to favorable soil conditions owing to an increase organic carbon in the soil with application of organic manure (Reddy *et al.,* 1998). The better growth of plant in terms of dry matter accumulation could also be attributes due to enhanced release of micronutrients from the added source of N, P and K. It also suggested that the release of nutrients on mineralization and changes in the physico-chemical properties of soil due to application of organic manure in the form of FYM thereby improve the nutritional status of soil. The interactive influence of mineral nutrients and FYM on growth might be due to improved physico-chemical and biological properties like water holding capacity, hydraulic conductivity and high rate of microbial transformations which make availability of organic carbon for heterotrophic organisms. It might act as stimulant for supply of crop nutrients during the decomposition. These results are in accordance with the finding as reported by Choudhary *et al.,* (2013), Farooq *et al.,* (2015) and Meena *et al.,* (2015) also reported higher release of nutrients from added organic sources, it were otherwise not available.

Effect of bio-fertilizers

The result of study revealed that the plant height, number of leaves per plant, chlorophyll content in leaves and, fresh and dry of weight of leaves in pooled data analysis were recorded significantly the maximum with the *Azospirillum* inoculation followed by PSB and it was minimum in control (no inoculation) (Table 1, 2, 3 and 4). Moreover, *Azospirillum* treatment was significant higher over the control but statistically at par with the PSB. Harse soil and climatic condition of arid region was not favour the multiplication of bios population therefore, we required a culture which extracted from local soil. But Application of *Azospirillum* improves nitrogen status of the soil because it acts as free nitrogen fixers. Efficient and healthy strain of *Azospirillum* in rhizosphere which, might has resulted in greater fixation of atmospheric nitrogen and consequently use by the plant resulting into vigorous growth. Similar results have been reported by Thamburaj (1991), Wange (1998) and Jayathilake *et al.,* (2002). Phosphate solubilizing bacteria (PSB) secrete anti-biotic substances and solubilize the otherwise unavailable insoluble soil phosphorus and then make it available to the plant. The inoculation of PSB bio-fertilizer increases the yield of crops by 10 to 30 per cent (Tilak and Annapurna, 1993). Results of present investigation showing that, the use of these bio-fertilizers significantly improved growth parameters. However, the improvement in these characters were found limited when these bio-fertilizers were used alone. These findings are agreement with earlier worker of Gowda *et al.,* (2007), Sharma (2014) and Meena *et al.,* (2015).

The present study conclude that concluded that application of 100% RD of NPK + 20 t ha^{-1} FYM is worth recommendable for farmers of arid region to make better growth and development of onion in nutrient deficient soil of arid region.

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