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Effect of Biofertilizer, Herbicide Application and Nitrogen Management on Growth, Productivity of Wheat (*Triticum aestivum* L.)

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A B S T R A C T

A field experiments was conducted during winter seasons of 2014-15 and 2015-16 at the Agricultural Research Farm, Indian Agricultural Research Institute, New Delhi to study the effect of biofertlizer, herbicides, nitrogen management on crop growth and yield of wheat. The treatment consisted of two biofertilizer viz. No biofertilizer and Azotobacter, two levels of herbicides, viz. no herbicide, Clodinafop-propargyl application in main plot and three times of nitrogen application, viz. Chemical fertilizer (recommended dose of urea), Natural fertilizer + chemical fertilizer (50:50) and Natural fertilizer +chemical fertilizer (25:75) in sub plot treatment, respectively. Inoculation of *Azotobacter* resulted higher growth attributes, yield attributes, seed yield. Significantly higher value plant height was recorded under *Azotobacter* inoculated as compared to uninoculated. Dry matter accumulation was higher with *Azotobacter* inoculated than uninoculated plants. The highest value of these attributes was recorded with the application of *Azotobacter* which was significantly higher that the control (No biofertilizer) in present experimentation. Inoculation of *Azotobacter* resulted higher number of grains per spike (58.06 and 60.85) and grain weight (6.71 and 6.89 g) which was significantly more than uninoculated plants. The 1000 seed weight of wheat significantly increased with the application of *Azotobacter*. The highest seed yield (45.77 and 46.72 q/ha) was recorded with *Azotobacter* application which was significantly higher than uninoculated control (38.98 and 46.72 q/ha) during 2014-15 and 2015-16, respectively. Similarly straw, biological yield and harvest index of the crop was also improved significantly with *Azotobacter* application as compared to control. The growth attributes i.e. plant height and dry matter accumulation were found higher in Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS while least growth attributes was recorded under untreated control during both the years. The treated plots exhibited significantly higher number of grains per spike (57.14 and 59.87), grain weight per spike (7.05 and 7.23 g) and 1000-grain weight than no weedicide control during respective years. The application of Clodinafop – Propargyl 60 g ha^{-1} at 30 produced significantly higher (45.15 and 46.62 q/ha) grain yield than untreated plots (36.59 and 40.57 q/ha). The nitrogen applied through urea or it was applied in combination with natural sources such as FYM had significant improvement on growth attributes and recorded higher plant height with 25% N applied through natural fertilizer + 75% nitrogen applied through urea recorded higher plant height than the other fertility treatments over the nitrogen applied through 50% natural + 50 % N applied through Urea. The combined application of 75% N by urea along with 25% natural fertilizer increased the number of effective tillers m^{-2}, number of grains per spike, length of spike and the test weight. The combined application of 25% N applied by natural fertilizers + 75 N through urea + micronutrients registered highest (44.47 and 45.94 q/ha) grain yield of wheat during 2014-15 and 2015-16 of study which was significantly higher than the treatments where 50% N through natural + 50% through urea fertilizers were applied.

Introduction

Wheat is the most important cereal crop which is badly infested with grassy as well as broad-leaf weeds. Since 1982 isoproturon is most widely used herbicide for management of Phalaris minor in wheat, particularly under rice-wheat cropping system. But, its efficacy has declined due to development of resistance in P. minor. However, the sole dependence on herbicide of single mode of action is also not advisable as it has contributed to shift towards difficult to control weeds and rapid evolution of multiple herbicides resistance, which is a threat to wheat production (Singh 2007).

Therefore, there is need to use mixture of herbicides in a way to lower the load on environment and improve weed control efficacy without any adverse effect on crop. Nitrogen (N) is the nutrient that most often limits crop production. Among major cereals, wheat requires 1 kg of N to produce 44 kg of wheat (Pathak *et al.,* 2003). Generally, more than 50% of the N applied is not assimilated by plants. Significant interaction between herbicide and nitrogen, where increased nitrogen found to enhance the performance of herbicide as well as N-scheduling not only influences the crop growth but also influences weed density and biomass also (Kim *et al.,* (2006). However, information in this regard is lacking. So, there is a greater need for new formulated herbicides with nitrogen rates and time of application to make out the effect of treatments on growth and yield of wheat.

Materials and Methods

The Field experiment was conducted on a field site during Rabi seasons for two consecutive years of 2014-15 and 2015-16 at the Agricultural Research Farm, Indian Agricultural Research Institute, New Delhi 110012, (28°38'N, 77°11E, 228.6 m above sea level) to study the Effect of nitrogen management and herbicide (Clodinafop-propargyl) on growth and yield of wheat in split plot design with three replications. The soil of the experimental field was sandy-loam in texture, low in organic carbon (0.542%), available nitrogen (159.90 kg/ha) and available phosphorus (10.63 kg/ha) contents while was medium in available potassium (168.73 kg/ha).

The soil reaction was near neutrality with slight alkaline tendency. The treatment consisted of two biofertilizer viz. No biofertilizer and *Azotobacter*, two levels of herbicides, viz. no herbicide, Clodinafop-propargyl application in main plot and three times of nitrogen application, viz. Chemical fertilizer (recommended dose of urea), Natural fertilizer + chemical fertilizer (50:50) and Natural fertilizer +chemical fertilizer (25:75) in sub plot treatment, respectively. Wheat variety 'HD-2967' was sown on 21 November, 2014 and 20 November, 2015 with 125 kg seed/ha by keeping row to row spacing of 22.5 cm during both the years of investigations, respectively.

The wheat seed used for sowing the plots receiving biofertilizer treatment was inoculated with *Azotobacter* obtained from the Division of Microbiology, IARI, New Delhi. Nitrogen applied as per treatment but full amount of P and K were applied at the time of sowing. Herbicides were dissolved in 600 liters water and applied at 30 days after sowing (DAS), using the knapsack sprayer fitted with flat fan nozzle.

Observations were recorded on growth, yield attributes and grain and straw yield as per standard procedure. Grain yield recorded in kg/plot was finally converted into grain yield kg/ha. All data were put to analysis of variance as described by Gomez and Gomez (1984). The mean assessment was accomplished by least significant difference (LSD) at 5% level of probability.

Results and Discussion

Effect on plant growth

The application of *Azotobacter* brought about significant improvement in term of plant height and dry matter accumulation in both years of experimentation. Significantly higher value plant height was recorded under *Azotobacter* inoculated as compared to uninoculated. Dry matter accumulation was higher with *Azotobacter* inoculated than uninoculated plants. It may also be noted that not only accumulation of dry matter was increased due to the effects of *Azotobacter* application, but translocation of dry matter as well as its efficiency were also found to be higher in crop plants applied *Azotobacter* as compared to control. Thus, improvement in plant height, dry matter accumulation is sufficient to indicate that dry matter partitioning was favorably influenced by *Azotobacter* application. The growth attributes i.e. plant height and dry matter accumulation were found higher in Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS while least growth attributes was recorded under untreated control during both the years. Plant height and dry matter accumulation in wheat crop were significantly higher in treated with Clodinafop – Propargyl 60 g ha^{-1} at as compared to that of untreated during both the years. The application of nitrogen through natural sources and chemical sources i.e. urea either in isolation or in combination had significant effect on the growth of wheat crop (Table 1). The nitrogen applied through urea or it was applied in combination with natural sources such as FYM had significant improvement on growth attributes and recorded higher plant height with 25% N applied through natural fertilizer + 75% nitrogen applied through urea recorded higher plant height than the other fertility treatments over the nitrogen applied through 50% natural + 50 % N applied through Urea. This might have resulted from the higher availability of nutrients and also the better growing conditions in the root zone created by the organic manures applied to the wheat crop. The higher plant height recorded in treatment receiving combined application 75% N by Urea + 25% by natural fertilizer had favourable impact on the dry matter accumulation by wheat and resulted in higher dry matter accumulation at all observational stages than the treatments receiving only N by urea or 50% by Urea + 50% by natural fertilizers. The higher dry weight of wheat could have been achieved through production of more number of tillers owing to the availability of all the nutrients especially nitrogen. The beneficial effect of N through fertilizers on growth of wheat had been reported earlier by many workers i.e. Singh *et al.,* (2011) and Tejalben *et al.,* (2017).

Effect on yield and yield attributes

The application of *Azotobacter* brought significant improvements in yield attributes like spike length, spike weight, number of grains per spike, seed weight per plant and 1000 seed weight. The highest value of these attributes was recorded with the application of *Azotobacter* which was significantly higher that the control (No biofertilizer) in present experimentation. Inoculation of *Azotobacter* resulted higher number of grains per spike (58.06 and 60.85) and grain weight (6.71 and 6.89 g) which was significantly more than uninoculated plants. The 1000 seed weight of wheat significantly increased with the application of *Azotobacter*. The lowest 1000 seed weight was recorded in control. Since seed size and protein content of particular genotypes are genetically-controlled characters, therefore such traits cannot be manipulated when the crop is grown under relatively high input condition. However, under control condition, reduction in seed size and protein content from the potential value of any particular genotype can be offset by biofertilizer application, which is very cost effective and is unique N-source that enters the plant system very quickly and effectively. Barik and Goswami, (2003) reported that use of 75% RDN (100 kg N ha^{-1} RDH) along with *Azotobacter* seed inoculation showed at par results of yield attributes (effective tillers/m^2, ear length and grains per ear) and yield.

The seed, straw and biological yield of wheat enhanced significantly with the application of *Azotobacter*. The highest seed yield (45.77 and 46.72 q/ha) was recorded with *Azotobacter* application which was significantly higher than uninoculated control (38.98 and 46.72 q/ha) during 2014-15 and 2015-16, respectively. Similarly straw, biological yield and harvest index of the crop was also improved significantly with *Azotobacter* application as compared to control. The higher value of yield attributing characters and finally yield of wheat was found due to application of *Azotobacter* indicating the synergistic effect of the micro organisms. Similar results confirm by Gawali *et al.,* (2018).

The application of post emergence of Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS recorded significantly higher number of spikes m^{-2}, number of grains per spike and 1000 grain weight than weedy check during both the years. The treated plots exhibited significantly higher number of grains per spike (57.14 and 59.87), grain weight per spike (7.05 and 7.23 g) and 1000-grain weight than no weedicide control during respective years. Shezad *et al.,* (2012) and Hamada *et al.,* (2013) confirms that the application of post-emergence Clodinafop-Propargyl formulations for controlling annual grassy weeds in wheat fields increased length of spike (cm), weight of spike (g), weight of 1000 grain (g), number of spikelet $spike^{-1}$, number of grains $spike^{-1}$ and wheat grain and straw yields (kg $plot^{-1}$). Wheat yield was affected remarkably by the weeds as in the present investigation. Uncontrolled weeds on an average caused 12.31 and 12.61 per cent reduction in the yield during 2014-15 and 2015-16, respectively as compared to post emergence application of clodinafop-propargyl. The reduction of wheat yield due to weed infestation amounted 30.7% to 61% compared to weed-free control. Fenoxaprop and clodinafop-propargyl were most effective in controlling *Phalaris minor* and *A. fatua* with maximum mortality of 86.76 and 85.52%, respectively. The application of Clodinafop – Propargyl 60 g ha^{-1} at 30 produced significantly higher grain yield than untreated plots. Bharat and Karchroo (2007) also reported superiority of tank mixing of clodinafop + metsulfuron methyl over isoproturon alone in broadening the spectrum of weed control and increasing yield. Malik *et al.,* (2013) found clodinafop 0.06 kg/ha very effective (95-98%) only against grassy weeds. clodinafop- propargyl + metsulfuron- methyl being at par with clodinafop *fb* metsulfuron 0.06 and 0.004 kg/ha recorded the number of spikes, 1000-grain weight and grain yield of wheat statistically similar to that of weed free check.

The combined application of 75% N by urea along with 25% natural fertilizer increased the number of effective tillers m^{-2}, number of grains per spike, length of spike and the test weight. The enhanced early vegetative growth in terms of higher dry matter accumulation and vigorous root system resulted in more number of tillers m^{-2} which consequently increased the number of ear bearing tillers significantly. The combined application of 75% N by urea along with 25% natural fertilizer also increased the number of grains per ear and test weight. However, in case of test weight, the treatment difference lacked significance including control (Table 2).

Table.1 Plant height, dry matter accumulation and yield attributes as influenced by biofertilizer, weed control and nitrogen management

Treatments	Plant height (cm)		Dry matter accumulation (g/plant)		Effective tillers (m^2)		Spike length (cm)		Spike weight (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Biofertilizer										
No biofertilizer	96.82	98.35	1572.23	1590.83	358.27	363.51	9.67	9.07	2.77	2.98
Azotobacter application	102.40	103.51	1652.75	1688.58	364.75	373.40	10.52	10.60	3.12	3.29
S.Em. (±)	0.53	0.70	3.39	5.19	0.57	0.61	0.05	0.06	0.02	0.02
CD at 5%	1.82	2.41	11.71	17.92	1.97	2.55	0.16	0.17	0.06	0.07
Weedicide application										
No weedicide	98.24	99.57	1590.72	1606.09	355.31	359.40	9.94	9.53	2.81	3.06
Clodinafop-propargyl application	100.97	102.29	1634.25	1673.32	367.71	377.50	10.25	10.15	3.08	3.21
S.Em. (±)	0.53	0.70	3.39	5.19	0.57	0.61	0.05	0.06	0.02	0.02
CD at 5%	1.82	2.41	11.71	17.92	1.97	2.55	0.16	0.17	0.06	0.07
Nitrogen management										
100% though Urea	100.45	101.83	1632.63	1661.62	364.66	371.67	10.19	10.12	2.96	3.19
50% Natural fertilizer + 50% Urea	95.91	96.89	1529.29	1550.12	347.12	351.38	9.80	9.13	2.77	2.84
25% Natural fertilizer + 75% Urea	102.46	104.06	1675.54	1707.38	372.75	382.31	10.30	10.27	3.10	3.37
S.Em. (±)	1.06	0.94	7.08	7.68	1.81	2.23	0.11	0.10	0.03	0.03
CD at 5%	3.17	2.81	21.05	23.04	5.41	6.89	0.33	0.31	0.09	0.10

Table.2 Yield and yield attributes as influenced by biofertilizer, weed control and nitrogen management

Treatments	No of grains per spike		1000 seed weight (g)		Seed weight (g) per plant		Grain yield (q/ha)		Straw yield (q/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Biofertilizer										
No biofertilizer	51.33	54.12	42.73	42.93	6.08	6.26	38.98	40.26	51.09	52.23
Azotobacter application	58.06	60.85	43.76	43.94	6.71	6.89	45.77	46.72	58.08	59.43
S.Em. (±)	0.56	0.62	0.09	0.07	0.05	0.06	0.20	0.29	0.37	0.30
CD at 5%	1.93	2.13	0.30	0.26	0.18	0.21	0.70	0.99	1.26	1.05
Weedicide application										
No weedicide	52.25	55.10	43.00	43.24	5.74	5.92	39.59	40.57	52.79	54.04
Clodinafop-propargyl application	57.14	59.87	43.49	43.63	7.05	7.23	45.15	46.42	56.38	57.62
S.Em. (±)	0.56	0.62	0.09	0.07	0.05	0.06	0.20	0.29	0.37	0.30
CD at 5%	1.93	2.13	0.30	0.26	0.18	0.21	0.70	0.99	1.26	1.05
Nitrogen management										
100% though Urea	55.21	58.07	43.34	43.57	6.41	6.59	41.68	42.67	54.89	56.04
50% Natural fertilizer + 50% Urea	49.30	52.20	42.55	42.75	5.76	5.93	40.97	41.87	51.79	53.15
25% Natural fertilizer + 75% Urea	59.58	62.20	43.84	43.99	7.01	7.21	44.47	45.94	57.07	58.29
S.Em. (±)	0.80	0.80	0.09	0.08	0.06	0.08	0.47	0.45	0.53	0.58
CD at 5%	2.39	2.40	0.26	0.24	0.19	0.23	1.40	1.36	1.60	1.75

Stimulated vegetative growth of wheat on account of adequate and prolonged supply of essential nutrients in treatments receiving natural fertilizer and micronutrients in addition to the 75% N through urea manifested itself in increased number of effective tillers m^{-2}, number of grains per ear and test weight. The cumulative effect of improved growth, increased dry matter accumulation and yield contributing characters significantly increased the grain yield of wheat. The combined application of 25% N applied by natural fertilizers + 75 N through urea registered highest grain yield of wheat during both the years of study which was significantly higher than the treatments where 50% N through natural + 50% through urea fertilizers were applied. The increase in grain and straw yield of wheat might be due to the increased availability of essential nutrients to the crop resulting from the cumulative effect of organic sources of nutrient applied to wheat crop. The harvest index of wheat also recorded a trend similar to grain yield but the treatment differences were short of significance. Chauhan, *et al, 2011*). Aleminew *et al.,* (2015).

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