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INTERACTIVE EFFECT OF WEEDICIDE AND NITROGEN FERTILIZER SOURCES ON THE GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

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To improve yield, weedicides are an essential component of production technology. This improvement in yield with pesticide application is only possible if the applied weedicide does not affect the main crop. Weedicide application poses two problems; environmental pollution, and negative interaction with the soil-plant nutrient system. The interaction of nutrient and weedicide restricts the uptake of nutrients which decreases the target yield. So, there is a need to manage the sources of nitrogen and weedicides not only for effective control of weeds but also for the improvement in crop yield. A study was conducted at the research area of the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad to check the interactive effect of weedicide and nitrogen fertilizer sources on the growth and yield of wheat. The experiment comprised of two combinations of nitrogen fertilizer sources that were; Urea+DAP and CAN+NP. The weedicide "Atlantis (Mesosulfuron methyl + Iodosulfuron methyl sodium)" was applied at different times (before, with and after nitrogen fertilizer application). Recommended rates of N-P-K (120-80-60 kg ha^{-1}, respectively) and weedicide (370 g ha^{-1}) were applied following the treatment plan (i.e. T_1 = Control (Without fertilizer and weedicide); T_2 = Urea+DAP (Weedicide applied before 2nd dose of urea); T_3 = Urea+DAP (Weedicide applied with 2nd dose of urea); T_4 = Urea+DAP (Weedicide applied after 2nd dose of urea); T_5 =CAN+NP (Weedicide applied before 2nd dose of CAN); T_6 = CAN+NP (Weedicide applied with 2nd dose of CAN); T_7= CAN+NP (Weedicide applied after 2nd dose of CAN)). The experiment was laid out according to Randomized Complete Block Design (RCBD). Sulfate of potash (SoP) was applied for potassium (K) in all the treatments at sowing. All P was applied at sowing while N was applied in splits. The fertilizer combination CAN+NP with weedicide application after the 2nd dose of CAN gave encouraging results; as plant height, chlorophyll contents and grain yield was increased up to 26.3, 30.8 and 18.1 % in comparison to that of weedicide applied at the same time in Urea+DAP combination. Thus, the combination of CAN+NP as a nutrient source with weedicide application after the 2nd dose of CAN could be beneficial for better crop quality/ yield.
Keywords: Weedicide, nitrogen fertilizer sources, urea+dap combination, can+np combination, yield of wheat.

INTRODUCTION

Wheat is cultivated on 8.5 million hectares (m ha) as a staple food in Pakistan, producing 21.1 million tons of grain yield with an average production of 2.5 million tons ha^{-1}. In Pakistan cereal crops, especially wheat and rice, contribute 80% to total cropland and also provide employment and food to millions of people. The population of the world is increasing day by day, which demands that food production should also be increased in the same pattern. A gap is present between the yield potential of the crop and actual produce due to many reasons (Ladha *et al*., 2003; Byerlee *et al*., 2003; Kumar *et al*., 2017).

Several factors are responsible for the reduction in yield of the wheat crop, but out of these factors, the most important one is weeds growth. Weeds are the unwanted plants in the field competing with main crops for nutrient, space, H_2O and CO_2. The presence of weeds in the field reduces the availability of nutrients to cash crops and thus limits their growth. Due to the presence of weeds, the yield could be reduced up to 20-40% (Oad *et al*., 2005), depending on the type, intensity and frequency of yield components. The weed issues are growing day by day due to intensive cropping system and improper irrigation techniques. Weeds management through hoeing, ploughing, harrowing, and cultivation practices is challenging without the use of weedicides. Complete removal of weeds from the crops can increase the yield up to 38%, and complete removal is only possible with the use of weedicides (Jalis and Shah, 1982).

While applying weedicide, it should be kept in mind that weedicide should have the least effect on the main crop. Weedicide may bind the nutrients, and thus plants become unable to take up nutrient from the soil, so the quantity and quality of weedicide should be selected wisely. Better

management of weeds and fertilizers minimizes the competition between weeds and the main crop; as a result, the yield is increased generating more revenue (Ehsanullah *et al*., 2009). Bender and Heijden (2015) have reported that yield could be increased by improving the fertilizer use efficiency and weeds management practices in which wise use of weedicide is most important.

Nitrogen fertilizer stimulates the vegetative growth of crop plants; as a result, the shade of crop plants suppresses the growth of weeds. The application of different levels of nitrogen with varying doses of herbicide gives different responses. Outcomes of various experiments showed that weed control by the use of weedicide along the use of nitrogen in split increases the crop yield, straw yield, decrease weed emergence and their mass (Chen *et al*., 2016). Farmers in Pakistan generally apply high doses of nitrogen to increase the yield. Weed infestation has elevated the attention to find a better strategy. Integrated Weed Management (IWM) is the best practice, including herbicides to minimize not only the negative effect of weeds on the main crop but also to reduce the number of seeds produced by weeds (O'Donovan *et al*., 2007). Facts on the impacts of many management practices, i.e. herbicides and fertilizer application are needed to flourish valid Integrated Weed Management (Malik *et al*., 1993; Jornsgard *et al*., 1996; Jarwar *et al*., 1999). Scientists reported that weed control by the chemical method would be more effective in comparison to other weed controlling techniques like cultural practices.

Management of weeds and fertilizer reduced the competition between weeds and crops of interest. Thus, net revenue becomes higher due to a decrease in losses by weeds (Ehsanullah *et al*., 2009). Therefore, it requires searching out a strategy to enhance the quality and yield of the wheat crop through suppressed weed competition. Based on the above discussion an experiment was planned to examine the interactive effect of weedicide and nitrogen fertilizer sources on the growth and yield of wheat (*Triticum aestivum* L.)

MATERIALS AND METHODS

A field trial with the collaboration of Fatima Fertilizer Company Ltd. was conducted at the research area of the Institute of Soil and Environmental Sciences (ISES), University of Agriculture, Faisalabad (UAF), to check the interactive effect of nitrogen fertilizer sources and weedicide on wheat growth. Representative soil samples were collected from 0-15 cm depth from the field and were analyzed for physicochemical properties (Table 1a, b) before sowing of the crop. Treatments were arranged according to randomized complete block design (RCBD). There were seven treatments (T_1 = Control (Without fertilizer and weedicide); T_2 = Urea+DAP (Weedicide applied before 2nd dose of urea); T_3 = Urea+DAP (Weedicide applied with 2nd dose of urea); T_4 = Urea+DAP (Weedicide applied after 2nd dose of urea); T_5 =CAN+NP (Weedicide applied before 2nd dose of CAN); T_6 = CAN+NP (Weedicide applied with 2nd dose of CAN); T_7= CAN+NP (Weedicide applied after 2nd dose of CAN)) and each treatment consisted of three replicates. Two combinations of fertilizer sources were used: (1) Urea+DAP+ SoP and (2) CAN+NP+ SoP. The weedicide "Atlantis (Mesosulfuron methyl + Iodosulfuron methyl sodium)" was selected and applied at the rate of 370 g per hectare. Nitrogen as CAN and/or Urea, P as DAP and/or NP and K as SoP were applied at recommended rates (120-80-60 kg ha^{-1}, respectively). Except for control (Without fertilizer and weedicide), required amounts of potassium and phosphorus (60 and 80 kg ha^{-1}, respectively) were applied at sowing time. At a seed rate of 100 kg ha^{-1}, wheat cultivar 'Faisalabad 2008' was sown by hand drilling on November 15, 2017. Five irrigations were applied with canal irrigation water. Wheat was harvested on April 19, 2018.

Table 1. Pre-sowing analysis of soil

a) Physical properties

Properties	Unit	Readings
Sand	%	49.03
Silt	%	27.40
Clay	%	23.57
Texture	-	Sandy Loam
Saturation Percentage	%	30

b) Chemical properties

Properties	Unit	Readings
ECe	dSm^{-1}	1.94
pHs	------	7.87
CEC	cmol$_c$kg^{-1}	13.50
Organic matter	%	0.78
Soluble Na	me L^{-1}	16.86
Extractable P	mg kg^{-1}	6.10
Extractable K	mg kg^{-1}	123.00
Total N	%	0.043

According to the treatment plan, nitrogen fertilizer (120 kg ha^{-1}) was applied in all treatments apart from control in two splits (after 25 and 45 days of germination) along with different weedicide timings, i.e. (a) Before: Application of weedicide 4-days before nitrogen application in the form of Urea or CAN, (b) During: Application of weedicide with nitrogen fertilizer application in the form of Urea or CAN and (c) After: Application of weedicide four (4) days after nitrogen fertilizer application as Urea or CAN.

Data regarding chlorophyll content were recorded at the vegetative stage. Plant height and leaf area were recorded at the maturity of the crop. The number of tillers, grain yield, straw yield, number of grains per spike and biological yield were recorded at harvesting. After harvesting plants, grains and straw were separated. For the analysis of chemical parameters, samples of straw and grains were collected and taken to the soil fertility and plant nutrition laboratory,

Institute of Soil and Environmental Sciences, UAF. Data were analyzed statistically through Fisher's analysis of variance method (Steel *et al*., 1997), using software Statistics-8.1. The mean comparison was done with the least significant difference (LSD) test.

RESULTS

***Plant height*:** Table 2 depicts data regarding the interactive effect of weedicide and N-fertilizer sources on the physiological and agronomic parameters of wheat. Fertilizer combination CAN+NP showed excellent results as compared to the combination Urea+DAP. When weedicide was applied after the second dose of N as CAN in CAN+NP combination (T_7), a 26 % higher plant height was observed in comparison to the same time of weedicide application in Urea+DAP combination, this is because N fertilization strengthened the plants before the application of weedicide to tolerate the stress effect. Results revealed that the height of wheat plants was affected significantly by the combination of nitrogen fertilizer and the time of application of weedicide. The combination of CAN+NP where weedicide was applied before, with and after the application of the 2nd dose of CAN showed relatively better results on plant height than that of the combinations of Urea+DAP where weedicide was applied at respective intervals.

***Chlorophyll contents*:** In CAN+NP combination chlorophyll contents were found 31% higher than the combination of Urea+DAP when weedicide was applied after the second dose of N. While weedicide applied with the second dose of N showed 31% higher chlorophyll contents in CAN+NP combination than Urea+DAP combination. Minimum chlorophyll contents were observed in treatment T_1 (control). The combination CAN+NP excelled combination Urea+DAP at all intervals (Table 2).

***Number of tillers per meter square*:** The number of tillers per meter square (Table 2) was significantly decreased (23% and 18%, respectively) in both fertilizer combinations CAN+ NP and Urea+ DAP, where weedicide was applied with the second dose of nitrogen fertilizer as CAN/Urea as compared to respective combination with weedicide applied after the second dose of CAN/Urea. The maximum number of tillers per meter square was found in T_7, which were 39% higher in comparison to T_4. The minimum number of tillers were observed in T_1 (control) that were 23 tillers per meter square.

Grain yield: Data depicted that 68% less grain yield was found in T_1 (control) as compared to treatment T_7 that was comprised of CAN+NP with weedicide application after the 2nd dose of nitrogen as CAN (Table 3). At the same time, the other combination of fertilizers with weedicide application after the second dose of urea (T_4) produced grain yield 15% less than T_7.

***Straw yield*:** As indicated in Table 3 straw yield was 18% less in treatment T4 (Urea+DAP with weedicide application after 2nd dose of Urea) than T7 (CAN+NP with weedicide application after the 2nd dose of CAN). Minimum straw yield (7193 kg ha^{-1}) was observed in T1 (control).

Table 2. Interactive effect of weedicide and nitrogen fertilizer sources on the physiological and agronomic parameters of wheat.

Treatment	Plant height (cm)	Chlorophyll content (SPAD)	Number of tillers m^{-2}
Control	34 F	28 E	284 G
Urea+DAP (weedicide applied before 2nd dose of urea)	51 E	35 D	380 E
Urea+DAP (weedicide applied with 2nd dose of urea)	43 D	32 D	368 F
Urea+DAP (weedicide applied after 2nd dose of urea)	57 C	39 BC	434 D
CAN+NP (weedicide applied before 2nd dose of CAN)	66 B	46 B	585 B
CAN+NP (weedicide applied with 2nd dose of CAN)	62 B	42 C	490 C
CAN+NP (weedicide applied after 2nd dose of CAN)	72 A	51 A	604 A
LSD	5.11	3.45	7.37

Table 3. Interactive effect of weedicide and nitrogen fertilizer sources on yield parameters of wheat.

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	1000 grain weight(g)
Control	1729 E	7193 G	23 F
Urea+DAP (weedicide applied before 2nd dose of urea)	4265 D	8500 E	28 E
Urea+DAP (weedicide applied with 2nd dose of urea)	4193 D	8100 F	26 E
Urea+DAP (weedicide applied after 2nd dose of urea)	4507 C	11433 D	32 D
CAN+NP (weedicide applied before 2nd dose of CAN)	4912 B	13247 B	38 B
CAN+NP (weedicide applied with 2nd dose of CAN)	4626 C	12233 C	35 C
CAN+NP (weedicide applied after 2nd dose of CAN)	5325 A	13900 A	42 A
LSD	18.16	0.066	2.296

***1000-grain weight (g)*:** A similar trend was observed for 1000-grain weight to that of grain and straw yield. Maximum thousand-grain weight (42 g) was noted in the treatment of CAN+ NP with weedicide application after 2nd dose of CAN (T7) which was 31% higher than treatment T_4 (Urea+ DAP with weedicide application after 2nd dose of Urea). But where weedicide was applied with the fertilizer (CAN or Urea) application, 1000-grain weight was significantly lowered in comparison to before and after CAN or urea. T1 (control) showed a minimum 1000 grain weight (Table 3).

***N concentration in grains*:** Chemical analysis of wheat grains has been illustrated in Table 4a, in which the percentages of N-P-K in grain were mentioned. Given Table revealed that in treatment T_7, which was CAN+ NP with weedicide application after 2nd dose of CAN, the nitrogen concentration in grains was 72% higher in comparison to that of T_4 (Urea+ DAP with weedicide application after 2nd dose of Urea). While, nitrogen concentration was decreased in grain in those treatments where weedicide was applied with the application of N fertilizer (either CAN or Urea) i.e., 47% and 25% in T_6 and T_3 in comparison to T7 and T4, respectively. Minimum N concentration was analyzed in T_1 (1% N).

***P concentration in grains*:** Minimum phosphorus concentration in grain (0.11%) was found in T_1 (control). The maximum concentration of P (0.33%) was observed in treatment T_7 that was CAN+NP with weedicide application after the application of 2nd dose of nitrogen as CAN followed by T5 (CAN+NP with weedicide application before 2nd dose of N as CAN) that were 50% and 61% higher in contrast to P concentration in T_4 (Urea+DAP with weedicide applied after 2nd dose of Urea) and T2 (Urea+DAP with weedicide applied before 2nd dose of Urea), respectively (Table 4a).

***K concentration in grains (%)*:** Potassium concentration in grain was significantly decreased in both fertilizer combinations CAN+ NP and Urea+ DAP, where weedicide was applied with the application of nitrogen fertilizer as CAN/Urea, as there was 17% and 15% less K in treatment T_6 and T_3 in comparison to T_7 and T_4, respectively (Table 4a). Potassium concentration was 0.89% in control that was minimum.

***N concentration in straw* (%):** Table 4b showed that N concentration in the straw of wheat was found maximum in treatment receiving CAN+NP with weedicide applied after 2nd dose of CAN (T7) followed by treatment receiving CAN+NP with weedicide applied before 2nd dose of CAN (T5) constituting 58% and 62% higher N in wheat straw than the same timing of weedicide application in other fertilizer combination (Urea+DAP) that was in treatment T4 and T2, respectively.

***P concentration in wheat straw (%)*:** The trend for P concentration in wheat straw was just similar to that of N concentration (Table 4b). CAN+NP with weedicide application before, with and after the 2nd dose of CAN induced 55%, 67 and 46% higher P in wheat straw, respectively to that of respective time of weedicide application in other fertilizer combination (Urea+DAP). However, the highest P concentration (0.19%) in wheat straw was found in T_7 (CAN+NP with weedicide applied after the 2nd dose of CAN).

***K concentration in wheat straw (%)*:** The highest K concentration in wheat straw was noticed where CAN+NP with weedicide application after the 2nd dose of CAN (T_7) was applied which was 3% (Table 4b). This was also proved that K concentration in wheat straw was strongly influenced by

Table 4(a). Interactive effect of weedicide and nitrogen fertilizer sources on the Chemical analysis of grain of wheat.

Treatment	N (%) in grain	P (%) in grain	K (%) in grain
Control	1.00 E	0.11 G	0.89 G
Urea+DAP (weedicide applied before 2nd dose of urea)	1.25 E	0.18 E	1.24 E
Urea+DAP (weedicide applied with 2nd dose of urea)	1.16 DE	0.14 F	1.15 F
Urea+DAP (weedicide applied after 2nd dose of urea)	1.45 CD	0.22 D	1.35 D
CAN+NP (weedicide applied before 2nd dose of CAN)	2.10 B	0.29 B	1.54 B
CAN+NP (weedicide applied with 2nd dose of CAN)	1.70 C	0.26 C	1.41 C
CAN+NP (weedicide applied after 2nd dose of CAN)	2.50 A	0.33 A	1.70 A
LSD	9.25	0.023	0.059

Table 4(b). Interactive effect of weedicide and nitrogen fertilizer sources on the Chemical analysis of wheat straw.

Treatment	N (%) in straw	P (%) in straw	K (%) in straw
Control	0.86 D	0.06 F	1.00 G
Urea+DAP (weedicide applied before 2nd dose of urea)	0.99 C	0.11 DE	1.45 E
Urea+DAP (weedicide applied with 2nd dose of urea)	0.96 C	0.09 E	1.25 F
Urea+DAP (weedicide applied after 2nd dose of urea)	1.20 BC	0.13 CD	1.67 D
CAN+NP (weedicide applied before 2nd dose of CAN)	1.60 BC	0.17 AB	2.00 B
CAN+NP (weedicide applied with 2nd dose of CAN)	1.40 AB	0.15 BC	1.80 C
CAN+NP (weedicide applied after 2nd dose of CAN)	1.90 A	0.19 A	2.40 A
	0.48	12.02	0.10

the timing of weedicide application in both the combinations, as in T_7 (CAN+NP with weedicide applied after the 2nd dose of CAN) and T_5 (CAN+NP with weedicide applied before the 2nd dose of CAN), there was 33% and 11% higher K in wheat straw than T_6 (CAN+NP with weedicide applied with the 2nd dose of CAN), respectively. Similarly, in Urea and DAP combination T_4 (Urea+DAP with weedicide applied after the second dose of urea) and T_2 (Urea+DAP with weedicide applied before the second dose of urea) induced 34% and 16% higher K concentration in wheat straw than T_3 (Urea+DAP with weedicide applied with the second dose of urea), respectively. However, weedicide applied after the second dose of N as CAN or Urea gave excellent results in both the combinations, but among combinations CAN+NP was found best regarding K concentration in wheat straw.

DISCUSSION

Nitrogen is important for the agronomic, physiological and yield parameters of wheat crop due to its role in the physiological and biochemical plant functions (Chen *et al*., 2016). Weeds present in the field compete for the uptake of nutrients (including N) to the main crop resulting in a decreased growth of the main crop. Weeds may reduce the yield up to 20-40% (Oad *et al*., 2005). If there is low weed density, the main crop will uptake more nutrients resulting in increased vegetative and reproductive growth. Nitrogenous fertilizers are also crucial for weed control by maximizing the vegetative growth of cereal crops, which showed a dominant effect on the weeds and suppressed those (Chen *et al*., 2016). This trial was conducted to check the interactive effect of N fertilizer and weedicide on the growth and yield of wheat. Results revealed that there was a significant role of weedicide applied at various times to the application of N-fertilizer in agronomic and physiological growth of wheat.

Results depicted that the CAN+NP combination gave better plant height than the Urea+DAP combination. This may be due to the slow release of nitrogen from CAN in comparison to Urea where only ammonium nitrogen is available for the plant. Plant uptakes the required amount of ammonium and remaining nitrogen is lost. This could also be due to the application of nitrogen fertilizer before weedicide application that made the weeds succulent after N-uptake and when weedicide was applied all the weeds died. Rehman *et al*. (2018) in their review, described that plant height was increased, while weeds density was decreased with N-fertilizer and weedicide application. Other researchers also revealed that plants height increased when we apply herbicide and nitrogen fertilizer interactively (Ali *et al*., 2000; Leghari *et al*., 2016; Razaq *et al*., 2017).

Chlorophyll contents were also found maximum in the CAN+NP combination where weedicide was applied at different times after and before nitrogen fertilizer application as CAN. This chlorophyll content increase was due to decreased weed density, which provides more space and lesser competition for the uptake of nutrients. Hernández and Munne-Bosch (2015) research work revealed that when the availability of nitrogen was increased, its uptake was also increased resulting in enhanced vegetative growth and leaf area index, thus optimum sunlight was fallen on the leaf which enhanced the chlorophyll contents in crop plants (Cooke *et al*., 2005; Filho *et al*., 2011). Some scientists also supported that more uptake of nitrogen also increased chloroplast which increased chlorophyll contents (Li *et al*., 2012).

An increase in the number of tillers is possible due to more space and for more space, there should be no competition in weeds and the main crop (Ali *et al*., 2000). Different researchers concluded that by the application of herbicide, weeds were controlled and nitrogen applied resulted in an improved number of tillers in wheat (Singh *et al*., 1985; Verma and Chaturuedi, 1885; Shahdeva *et al*., 1998).

Thousand-grain weight and grain yield are the essential yield parameters. In the grain yield and 1000-grain weight N-fertilizer played an important role. There are different reasons for the improvement of grain yield in the present study, which includes if growth is high grain yield will be better, maximum spike length also revealed more grain yield. Many scientists supported in their findings that, the application of N-fertilizer maximized the grain yield if weeds had controlled already (Walia and Gill, 1985; Mark and Ladonin, 1987; Abbas, 1988; Pandey *et al*., 1998).

Application of weedicide after the application of N-fertilizer sources as CAN/Urea enhanced the straw yield of wheat, and better performance was shown in CAN as N fertilizer source. Thus, where nitrogen was applied with weedicide (before and with) there was not too much increase in straw yield. This might be due to the trapping of nutrients by the weedicide. It was also supported by some researchers that, the application of weedicide and N-fertilizer at a time did not give meaningful results in the yield of straw, like Abbas (1988); Saini and Angiras (1998) and Shahdeva *et al*. (1998).

Timing of weedicide application with respect to N fertilizer application also influenced N, P and K concentration in grain and straw of wheat. This might be due to the suppressive effect of N fertilizer sources on weed development. Chen *et al*. (2016) showed a dominant effect of N fertilizer on weed growth.

So, it can be concluded from above mentioned results and discussion that weeds management fetch better results by using 'Atlantis' at the rate of 370 g ha^{-1}after and before the application of N as CAN plus NP. Even this combination proved a better fertilizers source over Urea plus DAP at their respective times of application.

***Conclusion*:** The research concluded that to get the optimum crop yield, it is of pivotal importance to select proper nitrogen fertilizer sources and the right time for weedicide application.

Application of weedicide before and after nitrogen application proved economically more profitable as compared to the application of weedicide with the fertilizer application. Moreover, selecting the suitable sources and time of application results in reduced cost of production. This strategy could be beneficial for enhancing the yield and growth of wheat and decreasing the losses by weeds, thus to explore this further research is needed to address this problem.

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