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**RESEARCH NOTE**

# Nitrogen and weed management effects on weeds and yield of barley in Kandahar, Afghanistan

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**ABSTRACT**

Growth and yield of barley (*Hordeum vulgare* L.) are highly influenced by nutrients and weed management. Nitrogen (N) is the most crucial nutrient to which barley crop responds readily. Efficient management of N and weeds can provide higher yield, better quality, and higher income to the farmers. Therefore, a field experiment was conducted in a split-plot design with three replications during winter season of 2019-20 in the Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan to evaluate the effect of weed and N management on weeds growth and barley productivity. There were three weed management options in main plots, such as weedy check, herbicide use alone [post-emergence application (PoE) of clodinafop-propargyl 60 g/ha + metsulfuron-methyl 4 g/ha (tank-mix) at 30 days after sowing (DAS)], and integrated weed management (IWM) involving stale seed bed 15 days before sowing + wheat crop residue (2.5 t/ha) retention + clodinafop-propargyl + metsulfuron-methyl (tank-mix) PoE with half of the recommended dose at 30 DAS]. Four N levels (~0, 40, 80 and 120 kg N/ha, *i.e.*, $N_0$, $N_{40}$, $N_{80}$ and $N_{120}$) were included as sub-plot treatments. The IWM led to significantly lower density and biomass of weeds at 40 and 70 DAS and significantly increased weed control efficiency (WCE) and weed control index (WCI). Clodinafop-propargyl (60 g/ha) + metsulfuron-methyl (4 g/ha) (tank-mix) PoE also resulted in significantly lower density and biomass of weeds and higher WCE and WCI than weedy check at all stages. IWM being at par with clodinafop-propargyl + metsulfuron-methyl (tank-mix) PoE led to higher growth (crop height, dry weight, leaf area index and growth rate) and yield of barley. On the contrary, the effect of nitrogen levels was not significant on the weed density and biomass reduction. $N_{120}$ and $N_{80}$ were comparable with respect to growth, yield attributes and yield of barley. Thus, IWM with 80 kg N/ha may be recommended for better weed management and higher barley yield and income in Kandahar, Afghanistan.

**Keywords**: Barley, Clodinafop-propargyl, Integrated weed management, Metsulfuron-methyl, Nitrogen

Barley is an important grain cereal and ranks fourth after wheat, rice and maize in both yield and area of cereal crops grown worldwide. It is grown widely in Afghanistan as forage and grain crop and used for consumption of humans, animals, and birds. Its productivity in Afghanistan is about 1.39 t/ha, which is much lower than the world average of 3.13 t/ha (FAOSTAT 2017). Weed competition and poor weed management are the major reasons for lower productivity of barley in Afghanistan, along with other factors like shortage of rainfall under rainfed condition, nutrients, and other inputs. Weeds are considered as one of the most serious biotic stresses and weed competition during critical period (15-30 DAS) of crop growth can reduce yield significantly. Thus, weed control is a key factor for obtaining high yield and income (Kaur *et al*. 2018). Hand weeding is cumbersome and costlier, therefore, using selective herbicides, IWM can be a best alternative and economical option.

Nitrogen (N) is the most essential nutrient for barley and its efficient management can provide higher yield, better quality, and higher income to the farmers. Weed control and N fertilizer applications have been studied widely in the world separately for its role and improving crop yield and quality. However, studies with respect to weed and N management together in a location-specific soil and climate condition on barley in Afghanistan are scanty. Thus, the present study was conducted to assess the effects of weed management and N doses on weeds growth and barley growth and yield.

The field experiment was conducted during winter season of 2019-20 at the Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan. Climate is semi-

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arid to sub-tropical with extreme cold and hot situations. Maximum and minimum temperature were 31°C and -10°C, and maximum and minimum relative humidity were 77.1% and 32.6%, respectively during crop growing season in 2019-20. Total rainfall received during crop growing season was 276.9 mm. Soil was sandy loam with pH 7.13, electrical conductivity 2.29 dS/m, organic carbon 0.3%, available N 125.4 kg/ha, available P 7.9 kg/ha and available K 159 kg/ha. The experiment was laid out in a split plot design with three replications. The main plot treatments were: three weed management options such as weedy check, herbicide use alone [post-emergence application (PoE) of clodinafop-propargyl 60 g/ha + metsulfuron-methyl 4 g/ha (tank-mix) at 30 days after sowing (DAS)], and integrated weed management (IWM) involving stale seed bed 15 days before sowing + wheat crop residue (2.5 t/ha) retention + clodinafop-propargyl + metsulfuron-methyl (tank-mix) PoE with half of the recommended dose at 30 DAS]. Four N levels (~0, 40, 80 and 120 kg N/ha, i.e., $N_0$, $N_{40}$, $N_{80}$ and $N_{120}$) were adopted as sub-plot treatments. For stale seed bed, irrigation followed by ploughing was done 15 days before sowing to allow weed emergence, and then ploughed to eradicate emerged weeds. Barley 'variety Darulaman 013' was sown using 100 kg seed/ha. Herbicides were applied using a knapsack sprayer fitted with flat fan nozzle at 30 DAS with respective doses as per the treatments. Nitrogen was applied in three equal splits: 1/3rd of N and full dose of P and K through urea, TSP, and potassium sulfate, respectively were applied as basal. Rest N was applied at CRI (first irrigation) and flowering stages. Species-wise weeds were collected at 40 and 70 DAS from all plots using a quadrat of 0.5 m × 0.5 m and categorized into narrow-leaved, broad-leaved, and total weeds. Weeds were dried for estimating species-wise and total weed dry weight (biomass). Weed data [population (density) and biomass] were statistically transformed (Das 1999). Weed control efficiency (WCE) based on weed density, weed control index (WCI) based on weed biomass and weed index (WI) were determined as per Das (2008). Barley plant height, dry matter accumulation, leaf area index, crop growth rate (CGR), grain yield and harvest index were recorded using standard procedures (Rana *et al.* 2014).

**Effect on weeds**

Major broad-leaved weeds that predominated the experimental field were *Carthamus lanatus* L. (Saffron thistle), *Lactuca serriola* L. (Prickly lettuce or milk thistle) and *Convolvulus arvensis* L. (Field bindweed). Major narrow-leaved weeds were *Cynodon dactylon* (L.) Pers. (Bermuda grass), *Bromus hordeaceus* L. (Barley brome or soft brome) and *Phalaris minor* Retz. (Littleseed canarygrass). Broad-leaved weeds were more dominant than grassy weeds. The occurrence and distribution of similar weeds flora has been reported by Ziar *et al.* (2017). Both IWM and herbicide use alone resulted in significantly lower weed density and biomass and higher weed control efficiency and weed control index than weedy check **(Table 1)**. But IWM resulted in highest reduction of density and biomass of narrow-leaved, broad-leaved and total weeds. It also had significantly higher WCE and WCI at all stages of growth. Several authors (Baghel *et al.* 2020, Das and Das 2018, Kaur *et al.* 2020; Punia *et al.* 2016, Rasmussen and Rasmussen 2000) have reported similar results. Among the nitrogen levels, lower weed density and biomass were recorded in $N_0$ treatment due to lack of N, which has role in promoting weed germination and growth. Thus, the density and biomass of weeds were less where nitrogen was not applied. Similar phenomenon was reported by Blackshaw *et al.* (2003) and Ma³ecka and Blecharczyk (2008). Lower density and biomass of weeds were obtained in IWM under no-fertilization. Maximum weed control efficiency and weed control index were found in $N_{80}$ treatment among the N management treatments at all stages of growth **(Table 1)**.

**Effect on barley crop growth and yield**

Among weed management treatments, IWM resulted in tallest barley plants, which were significantly taller than the other treatments at all dates except 70 DAS **(Table 2)**. This treatment led to significantly higher dry matter accumulation and leaf area index than herbicide use alone and weedy check treatments at all stages of growth. Better management of all three categories of weeds led to higher crop growth and canopy formation, which ultimately promoted higher vigour of barley crop in this treatment as reported by O'Donovan *et al.* (2001), Kumar *et al.* (2012) and Holm *et al.* (2006). In this treatment, crop residue retention could prevent weed germination, conserve moisture, and regulate soil temperature, which might have selectively favored barley crop and boosted up its growth. Crop residue on decomposition also might have supplied essential nutrients to soil resulting in greater plant height and higher values of growth parameters of barley. Higher the N level greater was the barley plant height, dry weight, leaf area index and crop growth rate (CGR). The values of these growth variables were highest at

$N_{120}$ treatment closely followed by $N_{80}$ **(Table 2)**. After sowing of barley on 27 November 2019, a very cold weather having weekly mean minimum temperature of -10°C prevailed, which affected crop growth heavily. Also, there was heavy rainfall for about a month. Therefore, crop growth was much lower than normal having shorter plants and stunted growth at initial/early stage. Again, crop assumed growth with normalcy of weather (Légère and Samson 2004; Ma³ecka and Blecharczyk 2008). Interaction between weed control and N level was significant for barley dry weight and CGR at 40 and 70 DAS but for plant height at 70 DAS **(Table 2)**. Greater plant height was associated with IWM combined with $N_{80}$ (~80 kg N/ha). Similarly, dry weight was higher in IWM x $N_{120}$ closely followed by IWM x $N_{80}$ at 40 DAS, but in IWM x $N_{80}$ closely followed by IWM x $N_{120}$ at 70 DAS. Possible reason could be that retention of crop residue, low weed pressure, and application of N might have been optimum for barley crop demand.

The IWM resulted in higher grain yield and harvest index **(Table 3)** among the weed management options, conforming Baghel *et al.* (2020), Nath *et al.* (2017), Puniya *et al.* (2016), and Das and Yaduraju (2012). Again, in accordance with growth, barley grain yield was highest in $N_{120}$ followed by $N_{80}$, but both the N levels were comparable and gave significantly higher grain yield than others. The effects of N itself and its doses played roles. Higher the dose of N, higher was the yield as reported earlier (Kohistani and Choudhary 2019, Ram and Buttar 2012, Meena and Mann 2010). Weed index (percent

**Table 1. Total weed density and biomass and weed control efficiency (WCE), weed control index (WCI) and weed index (WI) as affected by treatments in barley**

| Treatment | Total weed density (no./m²) | | Total weed biomass (g/m²) | | Weed control efficiency (%) | | Weed control index (%) | | Weed index (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 40 DAS | 70 DAS | 40 DAS | 70 DAS | 40 DAS | 70 DAS | 40 DAS | 70 DAS | |
| *Weed management* | | | | | | | | | |
| Weedy check | 53.7 | 141.3 | 0.40 | 3.21 | 0.0 | 0.0 | 0.0 | 0.0 | 24.1 |
| Herbicide use alone | 18.7 | 23. 7 | 0.15 | 0.34 | 60.7 | 78.6 | 58.6 | 88.1 | 6.6 |
| IWM | 9.3 | 8.3 | 0.10 | 0.29 | 81.9 | 90.9 | 72.6 | 87.8 | 0.0 |
| LSD (p=0.05) | 8.3 | 77.7 | 0.08 | 1.37 | 7.96 | 9.02 | 14.8 | 9.0 | 10.4 |
| *Nitrogen doses* | | | | | | | | | |
| $N_0$ | 21.8 | 42.2 | 0.23 | 0.89 | 40.0 | 53.1 | 44.3 | 56.1 | 41.1 |
| $N_{40}$ | 25.3 | 55.1 | 0.19 | 1.09 | 43.9 | 53.7 | 34.2 | 57.1 | 18.5 |
| $N_{80}$ | 36.0 | 58.2 | 0.29 | 1.40 | 54.8 | 60.9 | 52.2 | 60.0 | -6.7 |
| $N_{120}$ | 25.8 | 75.5 | 0.16 | 1.74 | 51.6 | 58.3 | 44.3 | 61.4 | -11.9 |
| LSD (p=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | 19.8 |
| *Interaction* | | | | | | | | | |
| LSD (p=0.05) | NS* | NS* | NS* | NS* | NS* | NS* | NS* | NS* | NS* |

* Non-significant; # Significant

**Table 2. Barley plant height, dry matter accumulation, leaf area index and crop growth rate (CGR) at different stages of growth as affected by treatments**

| Treatment | Barley plant height (cm) | | Dry matter accumulation (g/m²) | | Leaf area index | | CGR (g/m² (land area)/day) | |
|---|---|---|---|---|---|---|---|---|
| | 40 DAS | 70 DAS | 40 DAS | 70 DAS | 40 DAS | 70 DAS | 0-40 DAS | 40-70 DAS |
| *Weed management* | | | | | | | | |
| Weedy check | 8.5 | 12.7 | 9.2 | 58.7 | 0.13 | 1.28 | 0.23 | 1.65 |
| Herbicide use alone | 8.9 | 13.1 | 9.9 | 60.1 | 0.13 | 1.29 | 0.25 | 1.67 |
| IWM | 10.8 | 14.1 | 13.9 | 88.9 | 0.16 | 1.41 | 0.35 | 2.50 |
| LSD (p=0.05) | 1.67 | 0.93 | 1.09 | 4.31 | NS | 0.08 | 0.027 | 0.138 |
| *Nitrogen doses* | | | | | | | | |
| $N_0$ | 8.1 | 11.6 | 8.3 | 50.8 | 0.12 | 1.14 | 0.21 | 1.42 |
| $N_{40}$ | 9.2 | 13.3 | 9.9 | 67.2 | 0.13 | 1.24 | 0.25 | 1.91 |
| $N_{80}$ | 10.1 | 14.2 | 12.2 | 79.4 | 0.16 | 1.45 | 0.31 | 2.24 |
| $N_{120}$ | 10.2 | 14.5 | 13.6 | 79.5 | 0.15 | 1.49 | 0.34 | 2.20 |
| LSD (p=0.05) | 0.56 | 0.40 | 0.67 | 1.31 | 0.013 | 0.06 | 0.03 | 0.051 |
| *Interaction* | | | | | | | | |
| LSD (p=0.05) | NS* | S# | S# | S# | NS* | NS* | S# | S# |

* Non-significant; # Significant

**Table 3. Barley yield, harvest index and nutrient status after harvest as affected by treatments**

| Treatment | Grain yield (t/ha) | Harvest index (%) | Nutrient status in soil (kg/ha) | | |
|---|---|---|---|---|---|
| | | | Available N | Available P | Available K |
| Weed management | | | | | |
| Weedy check | 2.5 | 40.2 | 131.7 | 8.8 | 168.1 |
| Herbicide use alone | 3.1 | 38.5 | 139.0 | 9.4 | 145.1 |
| IWM | 3.5 | 39.8 | 160.3 | 9.0 | 232.7 |
| LSD (p=0.05) | 0.36 | NS | 6.7 | 0.08 | 9.5 |
| *Nitrogen doses* | | | | | |
| $N_0$ | 1.9 | 44.3 | 87.8 | 9.0 | 203.3 |
| $N_{40}$ | 2.7 | 37.1 | 126.8 | 6.5 | 176.8 |
| $N_{80}$ | 3.6 | 39.5 | 195.2 | 10.9 | 180.6 |
| $N_{120}$ | 3.7 | 37.1 | 204.8 | 10.0 | 167.2 |
| LSD (p=0.05) | 0.14 | 3.69 | 5.8 | 0.6 | 2.1 |
| *Interaction* | | | | | |
| LSD (p=0.05) | NS* | NS* | S# | S# | S# |

* Non-significant; # Significant

grain yield loss) was minimum in IWM, where a set of weed control methods applied (**Table 1**). $N_{120}$ and $N_{80}$ resulted in higher grain yield. The negative WI showed weed management superiority to even the best weed management option. Soil available N after harvest **(Table 3)** was higher in IWM and $N_{120}$ treatments, closely followed by $N_{80}$. In IWM, crop residue on gradual decomposition supplied nutrients to soil and increased N level, whereas in $N_{120}$ level, the N dose was responsible. Soil available P was higher in herbicide used alone and $N_{80}$ treatment, whereas soil available K was higher in IWM and $N_0$ treatments. Through better weed control, N, P and K removal by weeds were prevented and N, P, and K were reserved in soil and increased their content in soil. Crop residue retention also played a role. The K and N have synergistic effects and application of one of them increases requirement of other by crop. So, in $N_0$ treatment, N was not applied, and the absorption of K was lower by crop, which increased its status in soil.

Higher cost of cultivation was incurred due to IWM (36530 AFN/ha) and $N_{120}$ (34120 AFN/ha) treatments **(Table 4)**. The cost of cultivation of these treatments were higher because of more use of resources/inputs/practices (crop residue, stale seed bed, herbicides, and more amount of urea). Simultaneously, net returns and net benefit: cost were also significantly higher in these treatments. Already mentioned that higher barley yield was obtained in these treatments, which increased gross returns, net returns and net benefit: cost.

This study indicates that IWM led to better weed suppression and higher growth and yield of barley. Both 80 and 120 kg N/ha gave similar weed control and growth and yield of barley and were superior to

**Table 4. Cost of cultivation, gross and net returns (AFN/ha) and net benefit: cost of barley across the treatments**

| Treatment | Economics | | | |
|---|---|---|---|---|
| | Cost of cultivation ($\times 10^3$ AFN/ha) | Gross returns ($\times 10^3$ AFN/ ha) | Net returns ($\times 10^3$ AFN/ha) | Net B:C |
| Weed management | | | | |
| Weedy check | 26.03 | 79.02 | 50.56 | 1.8 |
| Herbicide use alone | 26.79 | 98.98 | 70.51 | 2.5 |
| IWM | 36.53 | 104.66 | 76.20 | 2.7 |
| LSD (p=0.05) | - | 12.57 | 12.57 | 0.44 |
| Nitrogen doses | | | | |
| $N_0$ | 24.85 | 59.57 | 31.10 | 1.1 |
| $N_{40}$ | 28.41 | 86.84 | 58.37 | 2.1 |
| $N_{80}$ | 31.27 | 111.43 | 82.96 | 2.9 |
| $N_{120}$ | 34.12 | 119.04 | 90.58 | 3.2 |
| LSD (p=0.05) | - | 3.16 | 3.16 | 0.12 |
| Interaction | | | | |
| LSD (p=0.05) | - | NS* | NS* | NS* |

* Non-significant; # Significant

other N doses. Applying 80 kg N/ha to barley would lead to a considerable saving of N (~40 kg/ha) without compromising yield. Therefore, IWM combined with application of 80 kg N/ha is economically and environmentally superior and may be recommended.

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