Nitrogen and weed management effects on soybean (*Glycine max* L.) yield in Kandahar, Afghanistan

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Summary

Soybean [*Glycine max* (L.)] ranks fourth among the most important crops in the world, following maize (1017 Mt), wheat (713 Mt) and rice (741 Mt). In 2014, soybean was grown in an area of about 111 M ha worldwide. The global production of soybean has shown a rising trend over the years (79 Mt in 1983, 115 Mt in 1993, 191 Mt in 2003, and 276 Mt in 2013). To assess the impact of weed and N management on soybean growth and productivity, a field experiment was carried out in a split-plot design with three replications during the spring season of 2020-21 at the Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan. The main plot treatments consisted of three weed management options, namely weedy check, pendimethalin 1 kg/ha at 1-2 DAS followed by 1 hand weeding at 25 DAS and pendimethalin 1 kg/ha at 1-2 DAS followed by Imazethapyr 100 g/ha at 25 DAS. The sub-plot treatments included four N levels (~0, 40, 60 and 80 kg N/ha, i.e., N0, N40, N60 and N80). Weed and N management had significant effects on all the growth parameters, yield attributes and yield of soybean. The highest values of plant height, leaf area index, DMA per plant, grain yield, Stover yield, biological yield and harvest index were recorded with the application of pendimethalin fb imazethapyr with 80 kg N/ha. Therefore, it is suggested that pendimethalin fb imazethapyr with 80 kg N/ha should be applied for effective weed control and higher soybean production and income in Kandahar, Afghanistan.

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Introduction

Soybean (*Glycine max* (L.) Merr.) Grows well in tropical, subtropical, and temperate climate zones with an ideal average temperature of 20– 30°C. Soybean seed is a major protein source for humans and animals worldwide. Also, it is a leading oilseed crop in the world providing 58% of global oilseed production (Board, 2013). Soybean is the fourth most important crop in the world, following maize (1017 Mt), wheat (713 Mt) and rice (741 Mt), soybean was planted on about 111 M ha globally. Although soybean cultivation is expanding in Afghanistan, there is a need to enhance its productivity by following integrated crop management practices. The challenges like lack of high-yielding varieties, poor crop management, low awareness of farmers, imbalanced fertilization, inadequate plant protection measures etc. affect the yield potential (NEI, 2016). Soybean requires a lot of (N) due to high protein content in the seed (about 40% and about 15% N). Soybean as a legume supplies N through the process of (N) fixation, the biological relationship between soybean and soil bacteria *Bradyrhizobim japonicum*. (N) fixation may provide up to 75% of the total required N. Soybean plants take up a large amount of (N) (about 330 kg N/ha for a yield of 4 t/ha) during the vegetation period, and the amount of (N) adopted in a plant adopted is highly correlated with the soybean seed yield (AKAO, 1991). Weed management is another important aspect as weeds are one of the most limiting factors for optimal crop growth and productivity. Soybean yield losses resulting from weed interference and the cost of weed control constitute some of the highest costs involved in crop production. Approximately, the monetary losses due to weeds in recent years have averaged about 17% of the crop value. Natural weed populations in most fields are high enough to cause devastating yield losses if left uncontrolled. The yield losses between 50 to 90% are common for soybean grown in un-weeded situations. Weeds compete directly with soybean for light, nutrients (especially N) and moisture and interference indirectly through the production and release of allopathic chemicals which inhibit crop growth. Fertilization helps in weed control indirectly by making soybean crops more competitive with weeds at an earlier stage than a poorly fertilized crop. Chlorophyll content in plants depends on soil N availability and crop N uptake, which are important management factors in arable farming for enhancing weed competitive attributes (De Silva et al. 2013). Nitrogen is the plant nutrient that is often most limiting to efficient and profitable crop production. In plants, an inadequate

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supply of available (N) frequently results in slow growth, low protein levels, poor yield and low-quality produce, and inefficient water use. Nitrogen-stressed plants often have greater disease susceptibility compared with properly nourished plants. However, excessive N can be detrimental to crop growth and quality, in addition to causing undesirable environmental impacts. Unlike other plant nutrients (like P and K), there is no universal or widely used soil test for the prediction of the amount of supplemental N required to meet the crop's needs. Instead, the need for N supplementation is typically based on yield expectations, field history, and measurement of residual NO3-. Nutrients in commercial fertilizers are generally soluble, so their availability to plants is quite predictable. However, most organic N sources require mineralization (conversion to inorganic forms) before they can be used by plants. Environmental factors such as soil temperature, pH, moisture, and management practices such as tillage intensity all impact the rate of N availability from organic sources (Mikkelsen & Hartz 2008).

However, the information on weed management and nitrogen management for enhancing the productivity of soybean in Afghanistan is lacking. Therefore, keeping the above facts in view, a field experimentation entitled "Nitrogen and weed management effects on productivity of soybean in Kandahar, Afghanistan" was conducted at ANASTU (Afghanistan National Agricultural Science & Technology University), Kandahar-Afghanistan with the following objectives.

1. To evaluate find out the effect of nitrogen and weed management on weed Interference in soybean.
2. To evaluate the effect of nitrogen and weed management on the growth and Productivity of soybean.
3. To evaluate the effect of nitrogen and weed management on the economics of soybean.

Materials and Methods

The study titled "Nitrogen and Weed Management Effects on Productivity of Soybean in Kandahar, Afghanistan" was carried out during March 2020-21 at the experimental farm of ANASTU (Afghanistan National Agriculture Science & Technology University). This part briefly describes the materials and methods used for taking observations from the study, processes and techniques followed during soil analysis in the laboratory and other computations made during the course of the study. The experimental design was arranged in a split-plot design with three replications. In main plots, three different weed managements (W1= Un-weeded check, W2= Pendimethalin 1 kg/ha at 1-2 DAS followed by 1 hand weeding at 25 DAS, W3= Pendimethalin 1 kg/ha at 1-2 DAS followed by Imazethapyr 100 g/ha at 25 DAS). In subplot, four different levels of N were, N_1= (Control plot: 0 kg N/ha (Full P and K:60-40), N_2=40 kg N/ha: 2 split (basal + at flowering) (Full P and K:60-40), N_3= 60 kg N/ha: 2 split (basal+ at flowering) (Full P and K:60-40), M_4= 80 kg/ha: 2 split (basal+ at flowering) (Full P and K:60-40). The plot size was 4 m length × 3 m width. The plant spacing was 50 cm × 10 cm using a seed rate of 80kg ha-1. The sowing date 12 March 2021. One border row from both sides of each plot was discarded, besides, 25 cm crop rows from the other two sides as a border effect.

Table 1. The physio-chemical properties of the experimental field

Soil properties	Unit	Before sown	Method
A. Mechanical **Sand**	%	68.28	International Dispersion
Silt	%	16.72	Method (Wright, 1939)
Clay	%	15	
Texture	Class	Sandy loam	USDA Textural Triangle
B. Chemical **Available N**	kg/ha	87.85	LaMotte Soil Test Kit
Available P	kg/ha	9.60	Olsen et al. (1954)
Available K	kg/ha	234.3	Hanway and Heidel (1952).
Organic Matter	(%)	0.74	Titration Method
Organic Carbon (%)	(%)	0.43	Walkely and Black method
EC	ds/m	0.52	Conductivity meter
pH	pH	8.4	pH meter (Elico pH meter model 2.112)

Climatic conditions

The climate of experimental site is generally desert type. The maximum and minimum temperature, relative humidity and mean weekly meteorological parameters during experimentation are presented.

Treatments of the experiment

Main Plots: Weed management

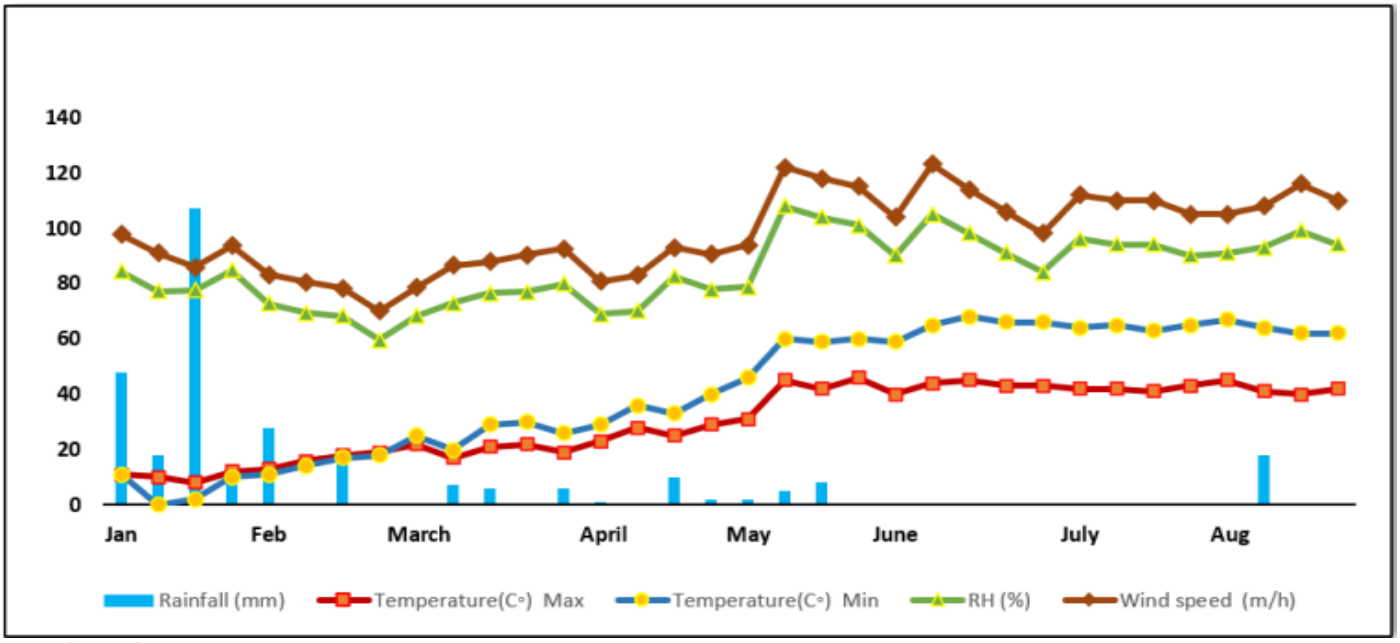
- W_1=Un-weeded check
- W_2=Pendimethalin 1 kg/ha at 1-2 DAS followed by 1 hand weeding at 25 DAS
- W_3=Pendimethalin 1 kg/ha at 1-2 DAS followed by Imazethapyr 100 g/ha at 25 DAS)

Sub Plot: Nitrogen management

- Control plot: 0 kg N/ha (Full P and K: 60-40)

- 40 kg N/ha: 2 split (basal+ at flowering) (Full P and K: 60-40)
- 60 kg N/ha: 2 split (basal+ at flowering) (Full P and K: 60-40)
- 80 kg/ha: 2 split (basal+ at flowering) (Full P and K: 60-40)

Figure 1 Weekly weather data recorded during crop growth period 2020-21



Result and Discussion

Effect of weed and nitrogen management on growth parameters

The height of the plants was significantly influenced by the weed management methods at all stages of crop growth at 30, 60, 90 DAS and harvest. The tallest plants (18.6 cm) at 30 DAS were observed with pendimethalin followed by imazethapyr, followed by pendimethalin fb hand weeding (17.6 cm) and un-weeded check (15.1 cm). The same trend was seen at 60 and 90 DAS, with pendimethalin fb imazethapyr having the highest plant height, followed by pendimethalin fb hand weeding. At the harvest stage, the highest plant height (62.4 cm) was recorded with pendimethalin fb imazethapyr, followed by pendimethalin fb hand weeding (59.8) and un-weeded check (54.3cm). The plant height was also significantly affected by the N management at all stages of crop growth at 30, 90 DAS and at harvest. The tallest plants (19.4 cm) at 30 DAS were observed with 80 kg N/ha, followed by 60 kg N/ha 18.2 (cm) and 40 kg N/ha (16.8 cm). The same trend was seen at 90 DAS, with 80 kg N/ha having the highest plant height (57.5 cm), followed by 60 kg N/ha (55.6 cm) and 40 kg N/ha (54.5cm). At the harvest stage, the highest plant height (60.9 cm) was recorded with 80 kg N/ha, followed by 60 kg N/ha (60.0 cm) and 40 kg N/ha (58.6cm). The LAI during all the growth stages was also significantly influenced by the different weed management methods. The highest LAI (2.94) at 30 DAS was observed with pendimethalin fb imazethapyr, followed by an un-weeded check (2.42) and pendimethalin fb hand weeding (2.36). At 60 and 90 DAS, the highest LAI was recorded with pendimethalin fb hand weeding, followed by un-weeded check and pendimethalin fb imazethapyr. The N management also had a significant effect on the LAI of soybean during all the growth stages. The highest LAI (3.20) at 30 DAS was observed with 80 kg N/ha, followed by the application of 60 kg N/ha (3.15) and the application of 40 kg N/ha (3.01). At 60 DAS, the highest LAI (4.97) was observed with 80 kg N/ha, followed by the application of 60 kg N/ha (4.90) and the application of 40 kg N/ha (4.85). At 90 DAS, the highest LAI (4.70) was observed with 80 kg N/ha, followed by the application of 60 kg N/ha (4.69) and the application of 40 kg N/ha (4.64). The DMA/plant at 60 and 90 DAS of crop growth was also significantly affected by different weed management methods. The variation in DMA of crop plant due to weed management was evident from the early stage of crop growth to the final stage of observation. There was no significant difference in the weeds management on DMA at 30 DAS. The highest DMA (16.66) at 60 DAS was observed with pendimethalin fb imazethapyr, followed by pendimethalin fb hand weeding (14.93) and the lowest was observed under un-weeded check (10.16). The highest DMA (36.95) at 90 DAS was observed with pendimethalin fb imazethapyr, followed by pendimethalin fb hand weeding (35.20) and un-weeded check (29.27). The N management also had a significant effect on DMA/plant at 60 and 90 DAS of crop growth. However, there was no significant difference in the DMA at 30 DAS. The highest DMA (17.63) at 60 DAS was observed with the application of 80 kg N/ha, followed by the application of 60 kg N/ha (15.68) and of application of 40 kg N/ha (12.47), respectively. The highest DMA (37.90) at 90 DAS was observed with the application of 80 kg N/ha, followed by application of 60 kg N/ha (35.72) and of application of 40 kg N/ha (32.46), respectively. The

lowest DMA was observed under control during all the growth stages.

Table 2. Nitrogen and weed management as affected by plant height (cm), leaf area index (LAI) and dry matter accumulation (g/plant)

Treatment	Plant height (cm)				Leaf are index (LAI)			Dry matter accumulation(g/plant)		
	Growth Stages				Growth Stages			Growth stages		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Main-plot: Weed management										
W_1: Un-weeded check	15.1	48.0	50.7	54.3	2.42	4.58	4.57	1.20	10.16	29.27
W_2: Pendimethalin fb hand weeding	17.6	52.3	55.3	59.8	2.36	4.98	4.44	1.81	14.93	35.20
W_3: Pendimethalin fb Imazethapyr	18.6	55.0	58.2	62.4	2.94	4.46	4.15	1.67	16.66	36.95
SEm±	0.19	1.11	0.23	0.11	0.15	0.13	0.17	0.19	0.27	0.22
LSD (P≤0.05)	0.75	4.49	0.94	0.44	0.48	0.42	0.54	NS	1.09	0.88
Sub-plot: Nitrogen management										
N_1: Control	13.9	34.1	51.2	55.9	2.27	4.81	4.49	1.57	9.89	29.17
N_2: 40 kg N/ha	16.8	56.8	54.5	58.6	3.01	4.85	4.64	1.29	12.47	32.46
N_3: 60 kg N/ha	18.2	57.1	55.6	60.0	3.15	4.90	4.69	1.64	15.68	35.72
N_4: 80 kg N/ha	19.4	57.7	57.5	60.9	3.20	4.97	4.70	1.74	17.63	37.90
SEm±	0.12	13.2	0.15	0.22	0.09	0.04	0.06	0.22	0.24	0.123
LSD (P ≤0.05)	0.34	NS	0.44	0.67	0.28	0.12	0.19	NS	0.71	0.37

Yield (t/ha) and harvest index

Soybean yield was significantly affected by weed management methods. The highest seed yield (2.20 t/ha) at harvest stage was observed with pendimethalin fb imazethapyr, followed by pendimethalin fb hand weeding (2.03 t/ha) and un-weeded check (1.65 t/ha). This difference was due to different N levels. The highest seed yield (g) (2.20 t/ha) was observed with 80 kg N/ha, followed by 60 kg N/ha (2.05 t/ha) and 40 kg N/ha (1.19 t/ha). The lowest seed yield (1.71 t/ha) was observed under control (0 kg N/ha). The stover yield of soybean was not significantly affected by different weed management methods. N levels had a significant effect on the stover yield of soybean. The highest stover yield (2.40) was observed with 80 and 60 kg N/ha, followed by 40 kg N/ha (2.35). The lowest Stover yield (1.92) was observed under control (0 kg N/ha). The biological yield was not significantly affected by different weed management methods either.

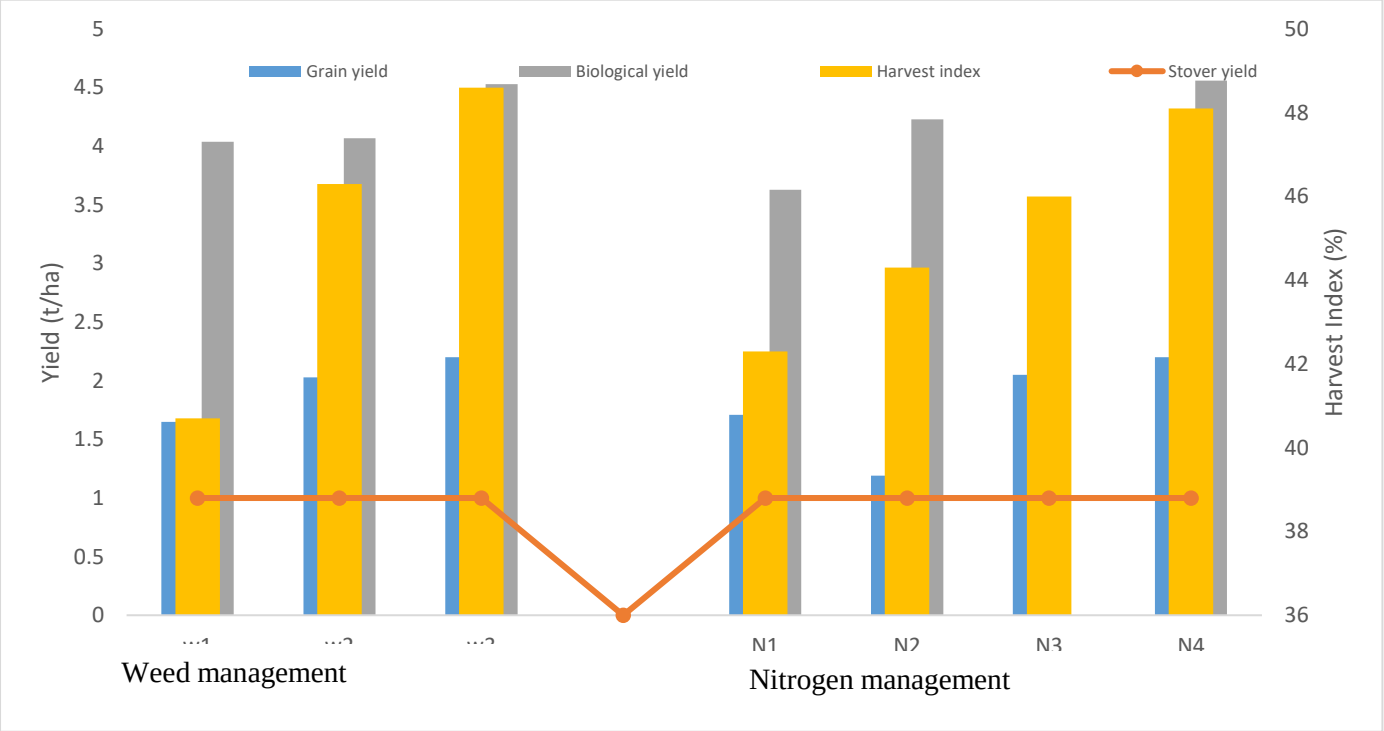
Table 3. Nitrogen and weed management as affected on seed yield, stover yield, biological yield and harvest index

Treatment	Seed yield (t/h)	Stover yield t/h)	Biological yield(t/h)	Harvest index (%)
Main-plot: Weeds management				
W_1: Un-weeded check	1.65	2.40	4.04	40.7
W_2: Pendimethalin fb hand weeding	2.03	2.04	4.07	46.3
W_3: Pendimethalin fb Imazethapyr	2.20	2.33	4.53	48.6
SEm±	0.21	2.12	1.96	0.90
LSD (≤0.05)	0.88	NS	NS	3.63
Sub-plot: Nitrogen management				
N_1: Control	1.71	1.92	3.63	42.3
N_2: 40 kg N/ha	1.19	2.35	4.23	44.3
N_3: 60 kg N/ha	2.05	2.40	4. 44	46.0
N_4: 80 kg N/ha	2.20	2.40	4.56	48.1
SEm±	0.12	0.15	0.20	0.6
LSD (≤0.05)	0.63	0.41	0.59	1.8

N management had a significant effect on biological yield at the harvest stage. The highest biological yield (4.56 t/ha) was observed with 80 kg N/ha, followed by 60 kg N/ha (4. 44 t/ha) and 40 kg N/ha (4.23 t/ha). The lowest seed yield (3.63 t/ha) was observed under control plots 0 kg N ha-1. The harvest index during the harvest stages was significantly affected by different weed management methods. Pendimethalin fb imazethapyr

had the highest harvest index (48.6%), followed by pendimethalin fb hand weeding (46.3%) and un-weeded check (40.7%). Nitrogen management had a significant effect on the harvest index at the harvest stage of soybean. The highest harvest index (48.1) was observed with 80 kg N/ha, followed by 60 kg N/ha (46.0) and 40 kg N/ha (44.3). The lowest harvest index (42.3) was observed under control (0 kg N/ha).

Figure 2. Yield and harvest index graph



Conclusion

The results of this experiment show that weed management and nitrogen management have significant effects on the growth, yield and harvest index of soybean. The best weed management method was pendimethalin followed by imazethapyr, which improved all the growth parameters such as plant height, dry matter, root weight, nodules, leaf area index (LAI), nodes per plant and internode distance. This method also resulted in the highest yield and harvest index at harvest time. The second best weed management method was pendimethalin followed by hand weeding, which showed the importance of integrated weed management and was much better than no weed control. The best nitrogen management method was applying 80 kg N/ha, which increased all the growth parameters as well as the yield and harvest index.

Declaration of Interests

The authors have no conflict of interest to declare.

Data Sharing

All relevant data are within the manuscript.

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