PERFORMANCE OF LENTIL VARIETIES TO THE APPLICATION OF NITROGEN LEVELS AND NITROGEN FIXING BACTERIA

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Abstract: Nitrogen is one of the most important macro nutrients because it is a major component of chlorophyll, involved in photosynthesis, protein synthesis and various other metabolic processes. A field experiment was conducted to study the performance of lentil varieties to the application of nitrogen levels and nitrogen fixing bacteria at Agronomy Research Farm, The University of Agriculture Peshawar in winter 2021. Two lentil varieties (Masoor-2006 and Markaz-09) were selected with five nitrogen levels (0, 10, 20, 30 and 40 kg ha^{-1}) and two nitrogen fixing bacteria (Azotobacter and Azospirillum). Sub plot of (1.8m x 3m) size were maintained having six rows. Row to row distance of 30 cm and plant to plant distance of 10 cm were maintained. A recommended dose of P @ 60 kg ha^{-1} was applied half each at the time of sowing while the remaining half was applied 30 days after sowing. The quantity of each bacterium culture was used @ 500 g ha^{-1} and was applied to the soil. Nitrogen application @ 30 kg ha^{-1} increased shoot fresh weight (5.1 g), shoot dry weight (2.2 g), chlorophyll index (35.1), leaf area (5.2 cm^2), leaf relative water content (48.7%), light interception (0.08%), fresh biomass weight at maturity (22.9 g) and dry biomass weight (10.3 g) at maturity. Application of nitrogen fixing bacteria increased shoot fresh weight (5.1 g), shoot dry weight (2.2 g), chlorophyll index (33.0), leaf area (5.2 cm^2), leaf relative water content (48.7%), light interception (0.08%), fresh biomass weight (20.6 g) at maturity and dry biomass weight (9.7 g) at maturity. However, between the two varieties Markaz-09 showed better response to nitrogen @ 30 kg ha^{-1} along Azotobacter application. It is concluded that, lentil variety Markaz-09 with Azotobacter and Nitrogen application @ 30 kg ha^{-1} could be better for improving lentil growth in agro climatic conditions of Peshawar region.

Key words: Lentil, Nitrogen, climatic condition, Peshawar.

INTRODUCTION

Lentil (*Lens culinaris* Med.) commonly called "Masoor'' belongs to Fabaceae family. Lentil is the second major Rabi crop after chickpea in Pakistan. It is a bushy annual plant known for its lens shaped seeds. The main lentil growing countries are China, Turkey, Bangladesh, Syria, Nepal, India, Canada and Turkey (Ahlawat, 2012). Lentils prefer loose, clayey soil rich in organic matter. It grows better in a soil with a PH between 6.0 and 6.5. It is a drought tolerant crop that can grow in irrigated and rainy areas. According to the data base of USDA national nutrient, 100g of fresh lentils give 353.0 calories of energy and 116 calories given by the same weight of cooked lentils. Raw lentils having 63% carbohydrates, 25% protein, 1% fats, 11% fiber and water 8% water. Lentils having the second highest ratio of protein after soybeans in legume crops.

Cultivated area of Lentil is 30.4 thousand hectares, and production of lentils is 14.60 thousand tons. The world total agricultural estimate is 4.6 million ha with seeds production of 4.20 million tons seeds being produced with 1095 kg per ha of production (MNFSR, 2015). Lentil occupied an area of 18.2 thousand hectare with an annual production of 8.1 thousand tones, thus giving an average seed yield of 445kg ha^{-1} in Pakistan, while 3.4 thousand hectare area and production of 1.7 thousand tones with an average yield of 500 kg ha^{-1} in KPK (Economic survey of Pakistan, 2016-2017).

Nitrogen is the important macro nutrient which is highly used in today's input of agriculture and the most important element in crop production (Latiri Souki *et al*., 1998). The cellular level, nitrogen increases the size and number of cells, and increase plant radiation absorption efficiency and also leaf area (Marbet, 2000). When nitrogen increases it also increase durability of the biomass and plant leaf area (Basso and Ritchie, 2005). The vital role of nitrogen in the plant is its presence in nucleic acids and in protein structure which are the most important structure and information substance of cells. Furthermore, nitrogen is also present in the chlorophyll that allows plant to transfer sunlight energy via photosynthesis. Hence, the nitrogen supply to plant will affect the quantity of amino acids chlorophyll formation, protein and protoplasm. Consequently, it influences leaf area, photosynthetic activities and cell size (Salvagiotti *et al*., 2008). Legume crops has a benefit over non-legume crops. Legumes crops fix atmospheric nitrogen for the use of plant and root-residues contribute nitrogen to soil for the subsequent crop. Nitrogen fixed by grain legumes can differ by crop, plant growth, residual soil nitrogen levels, climatic conditions and management practices. Nitrogen deficiency occurs almost everywhere except when the fertilizer is added. Many researchers are interested to the nitrogen fixation and the factors affecting that, because of the importance of N cycle in the fertility of agricultural lands (Postgate, 1998). Being a leguminous crop, lentil can have fixed atmospheric nitrogen by the help of symbiotic rhizobia in roots nodules and thus has potential in rotation for maintaining the fertility of soil. It can make use of atmospheric N_2 to fulfill its N requirements over biological nitrogen fixation (Badarneh, 1995).

Combination of N-fixing bacteria is products having living cells of different forms of microorganism. Increase in the production of dry matter and also nitrogen content of Azospirillum inoculated legumes may also have attributed early nodulation, increased nodules numbers, overall growth and development in root, maximum nitrogen fixation rate (Burdman *et al*., 1996). Increase in nodule formation may also explain, at least somewhat, with the help of promoting effect of

Azospirillum on root-hair formation and increased nod-gene secretion, induce signals to plant roots (Volphin *et al*., 1996).

In lentil production, there are a lot of limitations resulting in its low yield and production among them no application of compost and lack of suitable cultivar in our country. Apart from these factors, various other reasons for low yield of lentils are like growing in marginal land, high cost of inputs, ancient conventional methods of planting, ignorance of the growers about field exact management skill, and other practices related to field also decrease production of lentil. Without any application of fertilizers particularly with no application of N, this crop is sown by growers. For lentil, all genotypes are indeterminate and branched. Another reason for low lentil yield in Pakistan is the use of low yielding cultivars having low response to inputs and management methods, narrow adaptability to edaphic and climatic conditions and susceptibility to diseases. Varieties vary greatly in yield and yield components like number of branches plant per plant, number of seeds pod per pod and 1000 grain weight. So the yield on per unit area basis can be increased by the judicious use of fertilizers and selection of high yielding and fertilizer responsive genotypes.

Therefore, the present experiment was conducted to study the performance of lentil varieties to the application of nitrogen levels and nitrogen fixing bacteria under the agro-climatic conditions of Peshawar-Pakistan.

MATERIALS AND METHODS

To study the performance of lentil varieties to the application of nitrogen levels and nitrogen fixing bacteria, a field experiment was conducted at Agronomy Research Farm, The University of Agriculture Peshawar in winter 2021. Two lentil varieties (Masoor-2006 and Markaz-09) were sown. Five nitrogen levels (0, 10, 20, 30 and 40 kg ha^{-1}) and two nitrogen fixing bacteria (Azotobacter and Azospirillum). Sub plot of (1.8m x 3m) size were maintained having six rows. Row to row distance of 30 cm and plant to plant distance of 10 cm were maintained. A recommended dose of P @ 60 kg ha^{-1} was applied half each at the time of sowing while the remaining half was applied 30 days after sowing. The quantity of each bacterium culture was used @ 500 g ha^{-1} and was applied to soil. The research was consisting of following factors.

Factor-A Nitrogen levels (kg ha^{-1})

1. N_0 (Control) 2. N_1=10, 3. N_2=20, 4. N_3=30, 5. N_4=40

Factor-B Nitrogen fixing bacteria

1. Control, 2. Azotobacter, 3. Azospirillum

Factor-C Lentil varieties

1. Masoor-2006, 2. Markaz-09

The following parameters were studied in this experiment:

Shoot Fresh weight (g) at V5 stage, Shoot Dry weight (g) at V5 stage, Chlorophyll index, Leaf Area (cm^2), Leaf relative water content (%), Light interception (%), Fresh biomass weight (g) at maturity, Dry biomass weight (g) at maturity.

Statistical Analysis

The data were statistically analyzed by using analysis of variance techniques appropriate for randomized complete block design with split plot arrangement. Means were compared using LSD test at 0.05 level of probability, when the F-values are significant (Jan et al., 2009).

RESULTS

Shoot Fresh weight (g)

Data regarding shoot fresh weight of lentil varieties at V5 stage as affected by nitrogen levels with and without bacterium application is presented in table 1. Statistical analysis showed that N levels with bacterium application had a significant effect on fresh weight of lentil varieties (Masoor-2006 and Markaz-09) while N levels without bacterium application had a non-significant effect on fresh weight of lentil varieties. Bacteria when applied alone or in combination with N levels had a significant effect on fresh weight of lentil varieties. Maximum fresh weight (5.1g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 5.0g and 4.8g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The shoot fresh weight was decreased to 5.0 g from 5.1g when nitrogen rate was increased to 40 kg ha^{-1}. Minimum fresh weight (4.3g) was recorded in control plot. Azotobacter applied plots have maximum fresh weight (5.1g) as compared to Azospirillum and control plots.

Table 1. Shoot fresh weight (g) of lentil varieties as affected by nitrogen levels with and without bacterium application

Nitrogen levels (kg ha^{-1})		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	3.6	4.7	4.7	4.3
N 1	10	4.1	4.7	5.0	4.6
N 2	20	5.0	5.1	4.9	5.0
N 3	30	5.4	5.3	4.6	5.1
N 4	40	5.0	5.6	4.3	5.0
Masoor-2006		4.2	5.1	4.6	4.6
Markaz-09		5.0	5.0	8.8	5.0
Mean		4.6	5.1	4.7	

LSD value ($P \leq 0.05$) for Nitrogen levels = 0.4066
LSD value ($P \leq 0.05$) for Interaction (N x B) = **
LSD value ($P \leq 0.05$) for Varieties = 0.2571
LSD value ($P \leq 0.05$) for Interaction (N x V) = NS
LSD value ($P \leq 0.05$) for Bacteria = 0.3149
LSD value ($P \leq 0.05$) for Interaction (B x V) = *
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = ***

Shoot Dry weight (g)

Mean data about shoot dry weight of lentil varieties at V5 stage is presented in table 1. Statistical analysis showed that N levels with bacterium application had a significant effect on dry weight of lentil varieties (Masoor-2006 and Markaz-09) while N levels without bacterium application had a non-significant effect on dry weight of lentil varieties. Bacteria when applied alone or in combination with N levels had a significant effect on dry weight of lentil varieties. Maximum dry weight (2.2g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 1.9g and 1.8g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The shoot dry weight was decreased to 1.9g from 2.2g when nitrogen rate was increased to 40 kg ha^{-1}. Minimum dry weight (1.6g) was recorded in control plot. Azotobacter applied plots have maximum dry weight (2.2g) as compared to Azospirillum and control plots.

Table 2. Shoot dry weight (g) of lentil varieties as affected by nitrogen levels with and without bacterium application

Nitrogen levels (kg ha^{-1})		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	1.3	1.9	1.5	1.6
N 1	10	1.3	2.5	1.5	1.8
N 2	20	1.8	2.3	1.7	1.9
N 3	30	1.8	2.0	2.6	2.2
N 4	40	1.8	2.2	1.8	1.9
Masoor-2006		1.7	1.9	1.8	1.8
Markaz-09		1.4	2.5	1.9	1.9
Mean		1.6	2.2	1.8	

LSD value ($P \leq 0.05$) for Nitrogen levels = 0.2491
LSD value ($P \leq 0.05$) for Interaction (N x B) = ***
LSD value ($P \leq 0.05$) for Varieties = NS
LSD value ($P \leq 0.05$) for Interaction (N x V) = NS
LSD value ($P \leq 0.05$) for Bacteria = 0.1930
LSD value ($P \leq 0.05$) for Interaction (B x V) = ***
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = NS

Chlorophyll index

Statistical analysis showed that N levels with bacterium application had a significant effect on chlorophyll index of lentil varieties (Masoor-2006 and Markaz-09) while N levels without bacterium application had a non-significant effect on chlorophyll index of lentil varieties (Table 3). Bacteria when applied alone or in combination with N levels had a significant effect on chlorophyll index of lentil varieties. Maximum chlorophyll index (35.1) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 34.0, 33.3 and 32.1 with N application of 40 kg ha^{-1}, 20 kg ha^{-1} and 10 kg ha^{-1} respectively. Minimum chlorophyll index (24.6) was recorded in control plot. Azotobacter applied plots have maximum chlorophyll index (33.0) as compared to Azospirillum and control plots.

Leaf area (cm^2)

Data regarding leaf area of lentil varieties as affected by nitrogen levels with and without bacterium application is presented in table 4. Statistical analysis showed that N levels with and without bacterium application has a significant effect on leaf area of lentil varieties (Masoor-2006 and Markaz-09). Maximum leaf area (5.2 cm^2) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 5.0 cm^2 and 4.9 cm^2 with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The leaf area was decreased to 5.0 cm^2 from 5.2 cm^2 when N was applied @ 40 kg ha^{-1}. Minimum leaf area (4.8 cm^2) was recorded in control plot. Azotobacter applied plots have maximum leaf area (5.2 cm^2) as compared to Azospirillum and control plots.

Table 3. Chlorophyll index of lentil varieties as affected by nitrogen levels with and without bacterium application

Nitrogen levels (kg ha^{-1})		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	22.8	26.7	24.5	24.6
N 1	10	31.0	33.0	32.2	32.1
N 2	20	33.6	34.4	31.9	33.3
N 3	30	31.2	37.8	36.4	35.1
N 4	40	35.0	33.0	34.1	34.0
Masoor-2006		29.4	32.6	32.8	31.6
Markaz-09		32.0	33.3	30.8	32.0
Mean		30.7	33.0	31.8	

LSD value ($P \leq 0.05$) for Nitrogen levels = 1.5712
LSD value ($P \leq 0.05$) for Interaction (N x B) = **
LSD value ($P \leq 0.05$) for Varieties = NS
LSD value ($P \leq 0.05$) for Interaction (N x V) = NS

LSD value ($P \leq 0.05$) for Bacteria = 1.2171
LSD value ($P \leq 0.05$) for Interaction (B x V) = **
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = NS

Table 4. Leaf area of leaflet (cm^2) of lentil varieties as affected by nitrogen levels with and without bacterium application

Nitrogen levels ($kg\ ha^{-1}$)		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	4.1	4.8	5.6	4.8
N 1	10	5.0	5.2	4.5	4.9
N 2	20	4.7	5.3	4.8	5.0
N 3	30	5.3	5.5	4.8	5.2
N 4	40	4.7	5.3	5.1	5.0
Masoor-2006		4.4	5.2	4.8	4.8
Markaz-09		5.1	5.2	5.1	5.1
Mean		4.7	5.2	5.0	

LSD value ($P \leq 0.05$) for Nitrogen levels = 0.2294
LSD value ($P \leq 0.05$) for Interaction (N x B) = ***
LSD value ($P \leq 0.05$) for Varieties = 0.1450
LSD value ($P \leq 0.05$) for Interaction (N x V) = ***
LSD value ($P \leq 0.05$) for Bacteria = 0.1777
LSD value ($P \leq 0.05$) for Interaction (B x V) = **
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = *

Leaf relative water content (%)

Data related to leaf relative water content of lentil varieties is presented in table 5. Statistical analysis showed that N levels with and without bacterium application has a significant effect on leaf relative water content of lentil varieties (Masoor-2006 and Markaz-09). Maximum leaf relative water content (48.7%) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 47%, 46.8% and 43.4% with N application of 40 kg ha^{-1}, 20 kg ha^{-1} and 10 kg ha^{-1} respectively. Minimum leaf relative water content (39.5%) was recorded in control plot. Azotobacter applied plots have maximum leaf relative water content (48.7%) as compared to Azospirillum and control plots.

Light interception (%)

Light interception of lentil varieties as affected by nitrogen levels with and without bacterium application is presented in table 6. Statistical analysis showed that N levels with and without bacterium application has a non- significant effect on light interception of lentil varieties (Masoor-2006 and Markaz-09). Maximum light interception (0.08) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 0.07% and 0.06% with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. With N application of 40 kg ha^{-1} the light interception was decreased to 0.07% from 0.08%. Minimum light interception (0.04%) was recorded in control plot. Azotobacter applied plots have maximum light interception (0.08%) as compared to Azospirillum and control plots.

Table 5.Leaf relative water content (%) of lentil varieties as affected by nitrogen levels with and without bacterium application

Nitrogen levels (kg ha^{-1})		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	38.5	40.4	39.5	39.5
N 1	10	41.3	45.4	43.6	43.4
N 2	20	43.8	53.5	43.2	46.8
N 3	30	42.7	49.9	53.5	48.7
N 4	40	47.7	54.2	39.3	47.0
Masoor-2006		39.2	44.5	48.1	43.9
Markaz-09		46.4	52.8	39.5	46.2
Mean		42.8	48.7	43.8	

LSD value ($P \leq 0.05$) for Nitrogen levels = 3.5856
LSD value ($P \leq 0.05$) for Interaction (N x B) = ***
LSD value ($P \leq 0.05$) for Varieties = 2.2677
LSD value ($P \leq 0.05$) for Interaction (N x V) = ***
LSD value ($P \leq 0.05$) for Bacteria = 2.7774
LSD value ($P \leq 0.05$) for Interaction (B x V) = ***
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = **

Table 6. Light interception (%) of lentil varieties as affected by nitrogen levels with and without bacterium application

Nitrogen levels (kg ha^{-1})		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	0.03	0.06	0.04	0.04
N 1	10	0.05	0.07	0.05	0.06
N 2	20	0.06	0.08	0.07	0.07
N 3	30	0.07	0.09	0.08	0.08
N 4	40	0.05	0.09	0.08	0.07
Masoor-2006		0.05	0.07	0.07	0.06
Markaz-09		0.05	0.08	0.06	0.07
Mean		0.05	0.08	0.07	

LSD value ($P \leq 0.05$) for Nitrogen levels = 0.0074
LSD value ($P \leq 0.05$) for Interaction (N x B) = NS
LSD value ($P \leq 0.05$) for Varieties = NS

LSD value ($P \leq 0.05$) for Interaction (N x V) = NS
LSD value ($P \leq 0.05$) for Bacteria = 0.0057
LSD value ($P \leq 0.05$) for Interaction (B x V) = NS
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = NS

Fresh biomass weight at maturity (g)

Data analysis revealed that fresh biomass weight of lentil varieties was influenced by N levels and nitrogen fixing bacteria non-significantly (Table 7). Maximum fresh biomass weight (22.9g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 21.1g and 17.3g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The fresh biomass weight was decreased to 21.1g with N application of 40 kg ha^{-1} from 22.9g. Minimum fresh biomass weight (14.8g) was recorded in control plot. Azotobacter applied plots have maximum fresh biomass weight (20.6g) as compared to Azospirillum and control plots.

Dry biomass weight at maturity (g)

Mean data about dry biomass weight of lentil varieties at maturity as affected by nitrogen levels with and without bacterium application is presented in table 8. Statistical analysis showed that N levels with and without bacterium application has a non-significant effect on dry biomass weight of lentil varieties (Masoor-2006 and Markaz-09). Maximum dry biomass weight (10.3g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 10.1g and 8.5g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The dry biomass weight was decreased to 10.1g with N application of 40 kg ha^{-1} from 10.3g. Minimum dry biomass weight (6.0g) was recorded in control plot. Azotobacter applied plots have maximum dry biomass weight (9.7 g) as compared to Azospirillum and control plots.

Table 7. Fresh biomass weight (g) at maturity of lentil varieties as affected by Nitrogen levels with and without bacterium application

Nitrogen levels ($kg\ ha^{-1}$)		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	13.9	15.9	14.7	14.8
N 1	10	16.4	18.1	17.5	17.3
N 2	20	19.3	21.8	22.3	21.1
N 3	30	19.4	24.8	24.3	22.9
N 4	40	21.0	22.2	20.1	21.1
Masoor-2006		17.2	18.9	17.8	18.0
Markaz-09		18.8	22.3	21.8	21.0
Mean		18.0	20.6	19.8	

LSD value ($P \leq 0.05$) for Nitrogen levels = 2.1893
LSD value ($P \leq 0.05$) for Interaction (N x B) = NS
LSD value ($P \leq 0.05$) for Varieties = 1.38468
LSD value ($P \leq 0.05$) for Interaction (N x V) = NS
LSD value ($P \leq 0.05$) for Bacteria = 1.69588
LSD value ($P \leq 0.05$) for Interaction (B x V) = NS
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = NS

Table 8. Dry biomass weight (g) at maturity of lentil varieties as affected by Nitrogen levels with and without bacterium application

Nitrogen levels (kg ha^{-1})		Bacteria			Mean
		Control	Azotobacter	Azospirillum	
N 0	Control	5.5	6.6	6.0	6.0
N 1	10	8.0	9.0	8.6	8.5
N 2	20	9.5	11.1	9.6	10.1
N 3	30	9.3	11.4	10.2	10.3
N 4	40	9.7	10.6	10.1	10.1
Masoor-2006		8.5	8.8	8.8	8.7
Markaz-09		8.3	10.6	9.0	9.3
Mean		8.4	9.7	8.9	

LSD value ($P \leq 0.05$) for Nitrogen levels = 0.6615
LSD value ($P \leq 0.05$) for Interaction (N x B) = NS
LSD value ($P \leq 0.05$) for Varieties = 0.4183
LSD value ($P \leq 0.05$) for Interaction (N x V) = NS
LSD value ($P \leq 0.05$) for Bacteria = 0.5124
LSD value ($P \leq 0.05$) for Interaction (B x V) = ***
LSD value ($P \leq 0.05$) for Interaction (N*B*V) = *

DISCUSSION

Data collected in accordance with the procedure outlined in materials and methods on various parameters in the study are briefly discussed here in the light of relevant literature.

Statistical analysis of data regarding fresh weight of lentil varieties at V5 stage as affected by nitrogen levels with and without bacterium application showed that Different nitrogen levels with bacterium application had a significant effect on fresh weight of lentil varieties (Masoor-2006 and Markaz-09) while N levels without bacterium application had a non-significant effect on fresh weight of lentil varieties. Bacteria when applied alone or in combination with N levels had a significant effect on fresh weight of lentil varieties. Maximum fresh weight (5.1g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 5.0g and 4.8g with N application of 20 kg ha^{-}

^{1} and 10 kg ha^{-1} respectively. The shoot fresh weight was decreased to 5.0 g from 5.1g when nitrogen rate was increased to 40 kg ha^{-1}. Minimum fresh weight (4.3g) was recorded in control plot. The same results were reported by (Achakzai, 2001) stated that application of nitrogen shoot moisture content, leaf relative water content, plant height, primary branches plant^{-1} and secondary branches plant^{-1} were increased. Azotobacter applied plots have maximum fresh weight (5.1g) as compared to Azospirillum and control plots. These results were in line with (Burdman *et al*., 1996) findings reported the same effect of increasing fresh weight and dry weight with the inoculation of Azotobacter and Azospirillum.

Statistical analysis of data regarding dry weight of lentil varieties at V5 stage as affected by nitrogen levels with and without bacterium application showed that N levels with bacterium application had a significant effect on dry weight of lentil varieties (Masoor-2006 and Markaz-09) while N levels without bacterium application had a non-significant effect on dry weight of lentil varieties. Bacteria when applied alone or in combination with N levels had a significant effect on dry weight of lentil varieties. Maximum dry weight (2.2g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 1.9g and 1.8g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The shoot dry weight was decreased to 1.9g from 2.2g when nitrogen rate was increased to 40 kg ha^{-1}. Minimum dry weight (1.6g) was recorded in control plot. The same result was reported by Daur *et al*. (2008) stated that the shoot dry weight and dry matter production were increased with the application of different nitrogen levels. Azotobacter applied plots have maximum dry weight (2.2g) as compared to Azospirillum and control plots. The same effect of Azotobacter and Azospirillum was reported by Akhtar *et al*. (2009). They concluded that Azotobacter and Rhizobium have positive effect on fresh weigh, dry weight, growth and yield of lentil crop.

Statistical analysis of data regarding chlorophyll index of lentil varieties as affected by nitrogen levels with and without bacterium application showed that N levels with bacterium application had a significant effect on chlorophyll index of lentil varieties (Masoor-2006 and Markaz-09) while N levels without bacterium application had a non-significant effect on chlorophyll index of lentil varieties. Bacteria when applied alone or in combination with N levels had a significant effect on chlorophyll index of lentil varieties. Maximum chlorophyll index (35.1) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 34.0, 33.3 and 32.1 with N application of 40 kg ha^{-1}, 20 kg ha^{-1} and 10 kg ha^{-1} respectively. Minimum chlorophyll index (24.6) was recorded in control plot. These results were in line with (Salvagiotti *et al*., 2008) who also found with the application of nitrogen the quantity of amino acids, proteins, chlorophyll content and protoplasm were increased. Azotobacter applied plots have maximum chlorophyll index (33.0) as compared to Azospirillum and control plots. The recorded the same results and stated that nitrogen concentration and chlorophyll content were increased with the inoculation of Azotobacter and Azospirillum compared to control plots.

Statistical analysis of data regarding fresh biomass weight of lentil varieties at maturity as affected by nitrogen levels with and without bacterium application showed that N levels with and without bacterium application has a non-significant effect on fresh biomass weight of lentil varieties (Masoor-2006 and Markaz-09). Maximum fresh biomass weight (22.9g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 21.1g and 17.3g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The fresh biomass weight was decreased to 21.1g with N application of 40 kg ha^{-1} from 22.9g. Minimum fresh biomass weight (14.8g) was recorded in control plot. The same results were reported by (Latiri Souki *et al*., 1998) stated that application of nitrogen shoot moisture content, leaf relative water content, plant height, primary branches plant^{-1} and secondary branches plant^{-1} were increased. Azotobacter applied plots have maximum fresh biomass weight (20.6g) as compared to Azospirillum and control plots. Vessey. (2003) also reported the increase in fresh weight and dry weight in legumes with Azotobacter and Azospirillum inoculation with lentil seeds.

Statistical analysis of data regarding dry biomass weight of lentil varieties at maturity as affected by nitrogen levels with and without bacterium application showed that N levels with and without bacterium application has a non-significant effect on dry biomass weight of lentil varieties (Masoor-2006 and Markaz-09). Maximum dry biomass weight (10.3g) was recorded when N applied at the rate of 30 kg ha^{-1} followed by 10.1g and 8.5g with N application of 20 kg ha^{-1} and 10 kg ha^{-1} respectively. The dry biomass weight was decreased to 10.1g with N application of 40 kg ha^{-1} from 10.3g. Minimum shoot dry weight (6.0g) was recorded in control plot. The same results were recorded by in his findings stated that dry matter, dry weight, plant height and seed quality were increased with the application of nitrogen at different rates. Azotobacter applied plots have maximum dry biomass weight (9.7 g) as compared to Azospirillum and control plots. The same effect of Azotobacter and Azospirillum were reported by Singh et al. (2006) stated that Azotobacter and Rhizobium had significant effect on the dry weight, shoot fresh and dry matter, growth and yield of lentil crop.

Conclusion

It is concluded that:

- The growth and physiology of both lentil varieties had shown a significant response to nitrogen levels and nitrogen fixing bacteria and improvement in growth was obtained with nitrogen application alone and in combination with nitrogen fixing bacteria.
- From the above results it is concluded that lentil variety Markaz-09 has shown a positive response to Azotobacter and N application @ 30 kg ha^{-1}and has significantly increased the shoot fresh weight and dry weight both at vegetative stage and maturity. Also leaf area, leaf relative water content, Chlorophyll index and light interception were improved significantly.

On the basis of conclusions for improvement in growth,

- Lentil variety Markaz-09 with Azotobacter and Nitrogen application @ 30 kg ha^{-1} is recommended for agro climatic conditions of Peshawar region.

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