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Original article

The morpho-agronomic characterization study of *Lens culinaris* germplasm under salt marsh habitat in Swat, Pakistan

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ABSTRACT

The present research study evaluate and identify the most suitable and high yielding genotypes of *Lens culinaris* for the salt marsh habitat of Swat in moist temperate sort of agro climatic environment of Pakistan. A total of fourteen genotypes were cultivated and analyzed through Randomized Complete Block Design (RCBD). These genotypes were AZRC-4, NL-2, NL4, NL-5, NL-6, NARC-11-1, NARC-11-2, NARC-11-3, NARC-11-4, 09503, 09505, 09506, P.Masoor-09 and Markaz-09. Different parameters i.e., germination rate, flowering, physiological maturity, plant height, biological grain yield, seed weight, pods formation and its height, pods per plants and protein content were focused specially throughout the study. Preliminary the Lentil genotypes have significant variability in all the major morpho-agronomic traits. The days to germination, 50% flowering and 100 seed weight ranged from 7 to 9, 110 to 116 days, and from 5.4 to 7.3 gm respectively. Biological yield and grain yield ranged from 5333 to 9777 kg ha^{-1} and 1933 to 3655 kg ha^{-1} respectively. Whereas, protein contents ranged from 23.21% to 28.45%. It was concluded that the genotype AZRC-4 is better varity in terms of grain yield plus in 100 seed weight and moreover, 09506 genotype was significant under salt marsh habitat in early maturing for the Swat Valley, Pakistan.

1. Introduction

The Lentil (*Lens culinaris* Medic.) is one of the oldest annual leguminous crops belongs to family Papilionaceae. It was originated from salt marsh habitat in the South Western Asia in 6000 B.C. It was cultivated in 31 thousand hectare with 40,000 tones annual production with an average rate of 657 kg ha^{-1} (Erskine and Saxena, 1993). It is mostly grown in rain-fed areas, receiving 300–400 mm rain falls.

Due to high level of Protein content, other dietary products and minerals, it was very suitable for human utilization with a lower level of anti- nutritional factors (Rozan et al., 2001; Sharma and Banik, 2015). It is considered as poor's meat due to cheapest source of vegetable protein (22–34.6%) for under privileged group of people in the developing countries (Hariyappa, 2006). It contains 44.3% crude fiber and 63.1% starch (Sahi et al., 2000; Bhatty and Wu, 1974). Regarding its consumption in vegetarian cultures, it is consumed as soups, pies, snack and curries. Its leaves and young pods are used as vegetable in various part of the world. Furthermore, it is occasionally used as fodder, as green manure crop and the straw plus pods residues from thrashing have good feed value containing huge amount of proteins (Aman and Hatam, 2000). Regarding its cultivation, the most important cause of the low production of lentil was the cultivation in marginal land without application of fertilizer, poor management practice and cultivation of local variety as well as sub consciousness of farmers. For high productivity, the soil must be enriched with organic matter, mineral nutrient

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through development and adaptation of suitable agronomic management practices (Sadiq et al., 2001). It requires nitrogen in less quantity as compared to non-legume crops but phosphorus and potassium were essential nutrients for its higher and quality yield. Furthermore, lentil crop is grown to improve soil fertility by fixing atmospheric nitrogen through bacterial symbiosis (Mahmood et al., 2010). The factor that effect the yields of lentil were delayed maturity, lowered harvest index, disease infestation and frost damage (Whitehead et al., 2000). Lentil maturity is initiated by leaf senescence like other annual crops, which were triggered by plant hormones, drought and insufficient supply of nutrients especially Nitrogen (Conley et al., 2009). Because soil water availability and sites of soil Nitrogen mineralization were not controlled in dryland agriculture, soil nitrogen management and desiccant applications were the practical strategies to induce maturity in undefined crops (Gan et al., 2009; Menalled, 2015). Extensive vegetative growth, lodging and pod abortion due to limited light interception in the lower part of the canopy, excessive flower, pod shedding, competition between pods and vegetative parts for photosynthesis were all the consequences of indeterminacy and late maturity.

Improved cultivars contributed to increase lentil production in yield. In most lentil production regions yield resulted to be no more than one half of the potential cultivar yield and far below theoretical mix yield. This difference reflects a production constraint that prevents the realization of true genetic yield potential (Sabaghnia et al., 2008).

The present study is conducted to evaluate the morphological and biochemical traits of various lentil genotypes seed types to germination, days to Physiological maturity, 50% flowering, Pods formation, No of Pods per plant and Lowest pod Height from ground level. Furthermore, it also investigates the biological yield (kg ha^{-1}), grain yield (kg ha^{-1}), 100 seed weight and protein content.

2. Materials and methods

A total of 14 genotypes and 3 replicates for each genotype were observed through Randomized Complete Block Design (RCBD) under salt marsh habitat. The distance between plants and rows were kept 5cm and 30cm respectively. Each plot comprised of 4 rows with 4 meter length. Lentil crop was reserved free from weeds, insects and pests. In order to know the soil chemistry of the field, soil samples were analyzed i.e., pH, electrical conductivity, Lime percentage, organic matter concentration, nitrogen, phosphorus and potassium concentration through various parameters before sowing (Ahmad et al., 2016; Bibi et al., 2016; Iqbal et al., 2015; Khan et al., 2016, 2014; Khan 2012). The recommended morpho-agronomic traits were recorded, which includes Germination data, Days to physiological maturity and 50% flowering was collected after the sowing date. The physiological data were collected, when 70–80% plants become matured. Pods per plant were calculated from each plot from 10 randomly selected plants and then mean values were calculated. Biological yield of two matured central rows were randomly selected and weighted kg/ha. While the Grain yields kg ha^{-1} two central rows of each plot in all the replications were harvested, sundried and weighed. The obtained data were then changed into kg/ha by means of formula given below:

$$\text{Grain Yield}\,\frac{\text{kg}}{\text{ha}} = \frac{\text{Economic yield}}{2a\ \text{Plot Size}}\ 10000\ \text{m}^2$$

From each plot randomly 100 Seeds were taken, weighted and its mean values were calculated. While height of the lowest pod above ground level was measured in centimeter. Chemical analysis of Crude protein was calculated from the N content, using the 6.25 coefficient. True protein was determined following the Bernstein method Nitrogen content, determined by the Kjeldhal method and expressed with reference to the dry matter of the sample (Seline and Johein, 2007). Each sample was twice analyzed. The amino acid was analyzed by HPLC after hydrolysis of the flour samples with 6 N HCl at 110 °C under vacuum for 24 h on an amino acid analyzer (Applied Bios stems 421 amino acid analyzer).

3. Results

A total of fourteen genotypes were studied to evaluate the most suitable high yielding genotypes of *Lens culinaris* for agro climatic environment under salt marsh habitat of Swat, Pakistan. These genotypes were AZRC-4, NL-2, NL4, NL-5, NL-6, NARC-11-1, NARC-11-2, NARC-11-3, NARC-11-4, 09503, 09505, 09506, P. Masoor-09 and Markaz-09. The results obtained during research work, summarized and parameter-wise details are presented as:

3.1. Days to germination

The total 14 genotypes of lentil for various yields related to morpho-agronomic traits were studied. Initially data regarding number of days to germination (seedlings) was statistically significant. Maximum days to 50% germination were observed in genotypes NL-2, NARC-11-1 and 09503, whereas minimum numbers of days were observed in all remaining genotypes (Fig. 1).

3.2. Days to physiological maturity

The days to physiological maturity were extensively affected by many lentil genotypes. The recorded time for physiological maturity were ranged from 149–169 days. Among the tested genotypes, three genotypes i.e., 09506, Markaz-09, 09505 and P. Masoor were observed early matured availing 149, 150 and 150 days respectively. The lentil genotypes AZRC-4, NL-4 and NL-6 show late maturity taking 169 days correspondingly (Fig. 2).

3.3. Days to 50% flowering

The days to 50% flowering among the tested lentil genotypes ranged from 110 to 116 days. Maximum number of days to 50% flowering (116.33) were taken by genotypes NARC-11-1 followed by genotypes NARC-11-2 (116), while minimum days to 50% flowering (110) were recorded in genotypes NL_6 respectively (Fig. 3).

3.4. Days to pods formation

The present research work showed that the pods formation was significantly affecting among lentil genotypes. The maximum days for pods formation were observed in genotype NARC-11-2 followed by genotype NL-2 whereas minimum days were recorded in genotype Markaz-09 (Fig. 4).

3.5. No of pods per plant

The significant variations in number of pods per plants were investigated in various genotypes i.e., genotype AZRC-4 produces highest number of pods (123 per plant), which is followed by NL-2 that producing 104 pods per plant. Poor performance was shown in the genotype NARC-11-4 and NARC-11-1 respectively (Fig. 5).

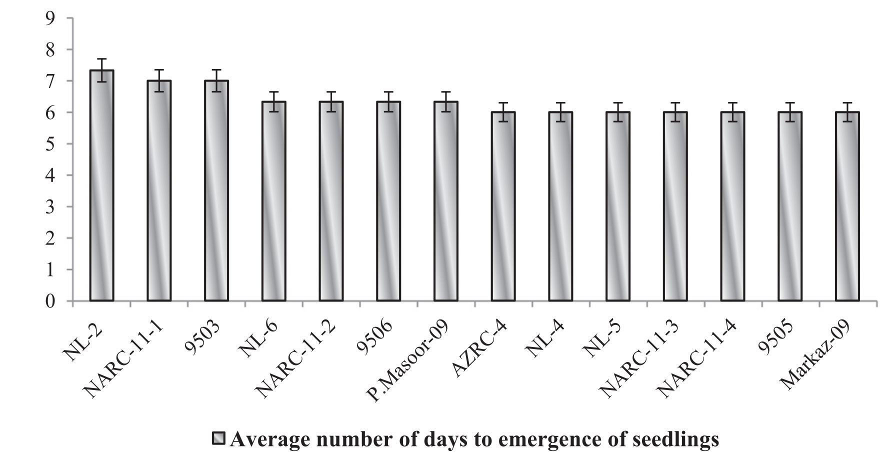

Fig. 1. Number of days to germination of 14 various lentil genotypes in Swat, Pakistan.

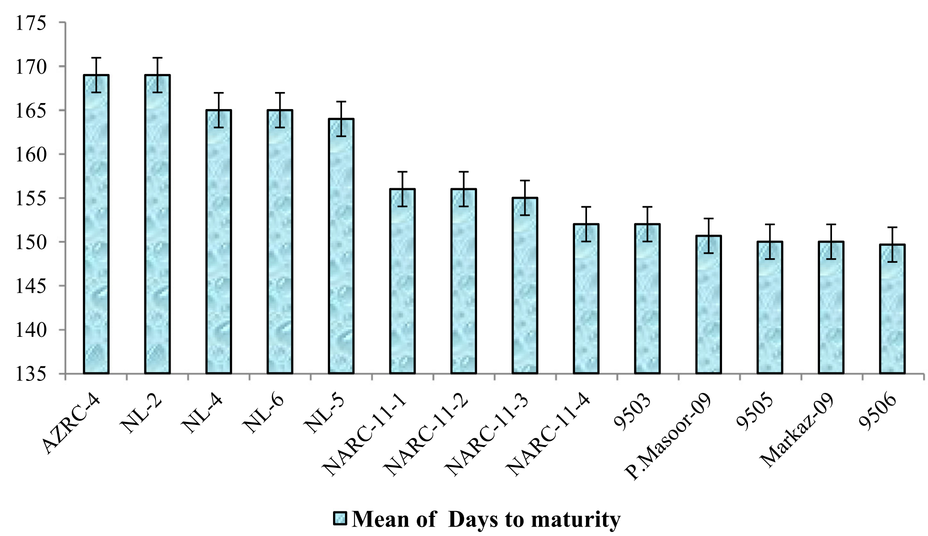

Fig. 2. Days to Physiological maturity of various lentil genotypes in study area.

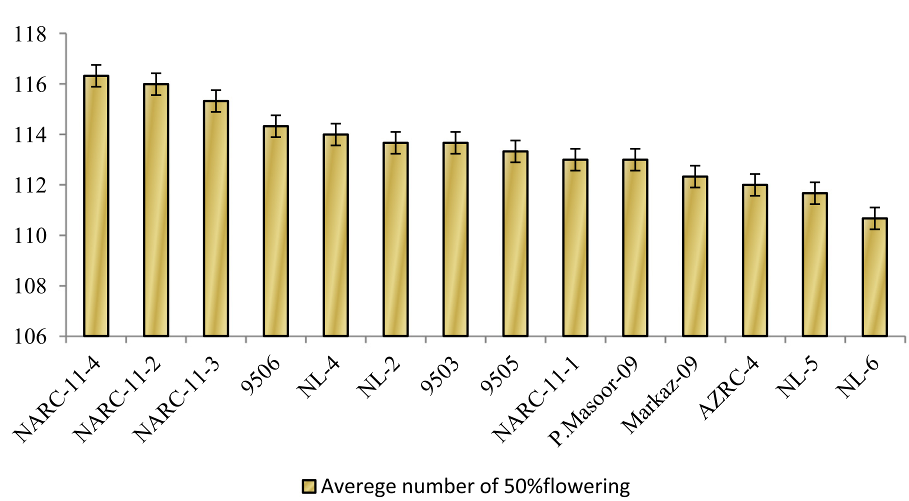

Fig. 3. Days to 50% flowering of various *Lens culinaris* genotypes.

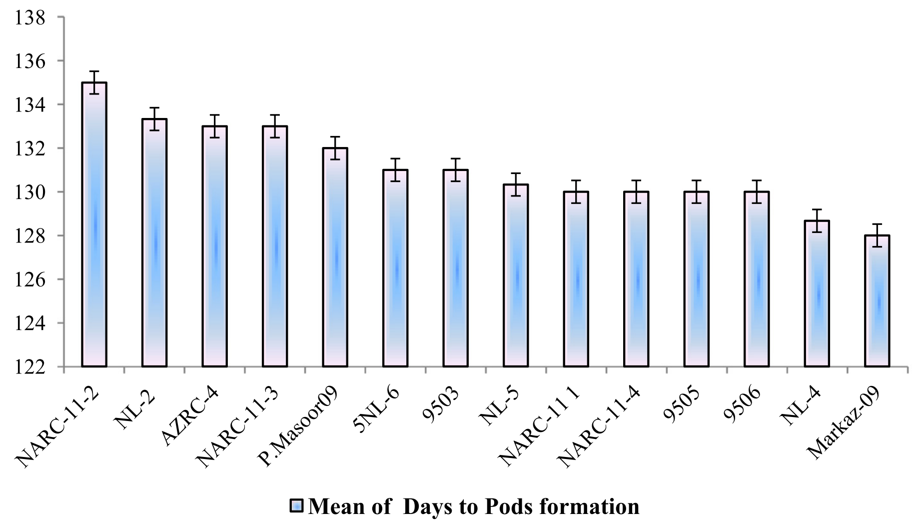

Fig. 4. Diagram represents number of days to pods formation of lentil genotypes.

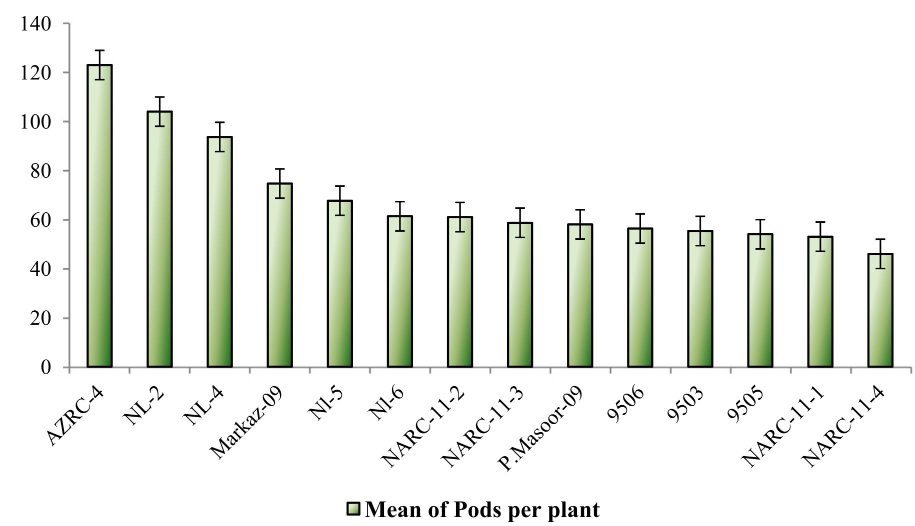

Fig. 5. Variations in number of pods per plants in 14 various lentil genotypes in swat, Pakistan.

3.6. Lowest pod height from ground level

In the genotype AZRC-4 maximum height of the lowest pod were observed, which is 2.97cm from the ground level, followed by NL-5 having 2.23cm height of the lowest pod. While minimum height of the lowest pod (0.793) was obtained in the genotype NL-2 (Fig. 6).

3.7. Biological yield (kg ha^{-1})

Regarding biological yield, the genotype 09503 produces maximum yield up to 9777 kg ha^{-1} which is followed by genotypes Markaz-09 having 9555 kg ha^{-1}, while the genotype NL-2 have minimum biological yield up to 5333 kg ha^{-1} (Fig. 7).

3.8. Grain yield (kg ha^{-1})

The grain yield data revealed significant effect of lentil genotypes. The maximum grain yield was recorded from genotypes AZRC-4 up to 3655.6 kg ha^{-1}, followed by genotypes 09506 with 3455.6 kg ha^{-1} production. The P.Masoor-09 was the deprived genotype among all regarding the grain yield having 1933.3 kg ha^{-1} production (Fig. 8).

3.9. Weight of 100 seeds

The 100 seed weight in various lentil genotypes ranging from 5.4 to 7.3 g. The genotype AZRC-4 was the heaviest seed with 7.3 g/100 seeds weight, followed by 09503 recording 7.1 g/100 seeds while genotype markaz-09 show lowest seed weight with 5.4 gm per 100 seeds weight (Fig. 9).

3.10. Protein content

The statistical analysis of protein content shows that the genotype Markaz-09, containing maximum amount of protein (28.45%), followed by genotypes NL-2 (28.24%). Whereas genotype NL-5 shows minimum amount of protein contents [23.21%] (Fig. 10).

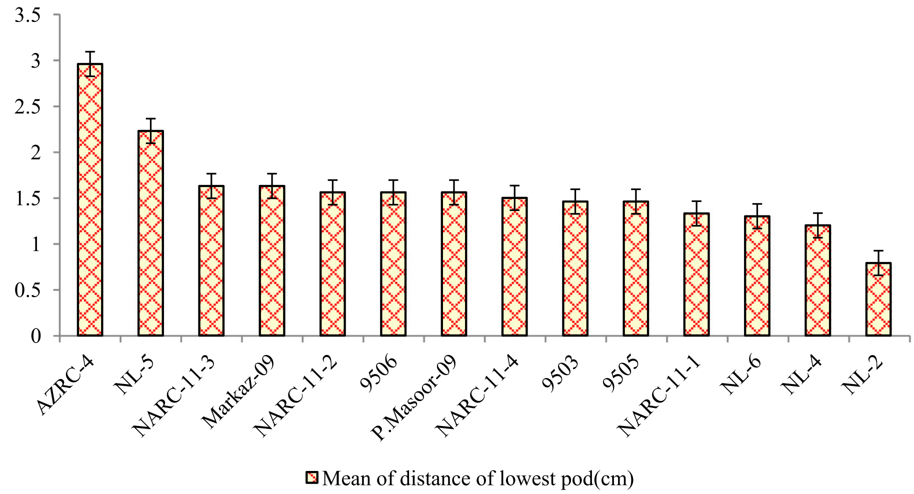

Fig. 6. Height of the lowest pod from ground surface.

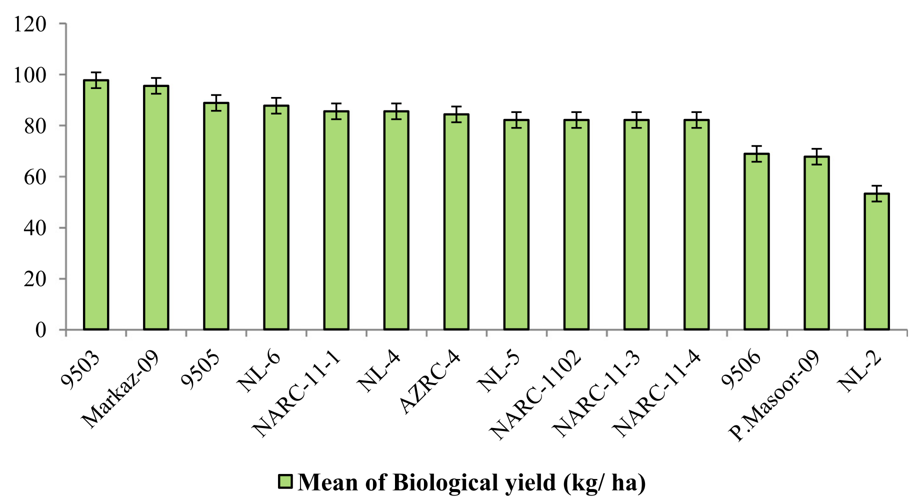

Fig. 7. Biological yield (kg/ha) of lentil genotypes in study area.

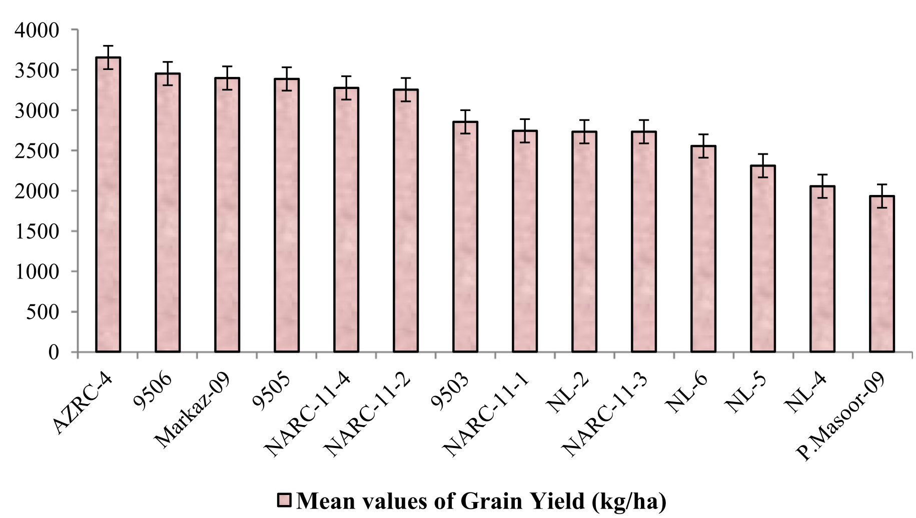

Fig. 8. Average values of grains yield of different lentil genotypes.

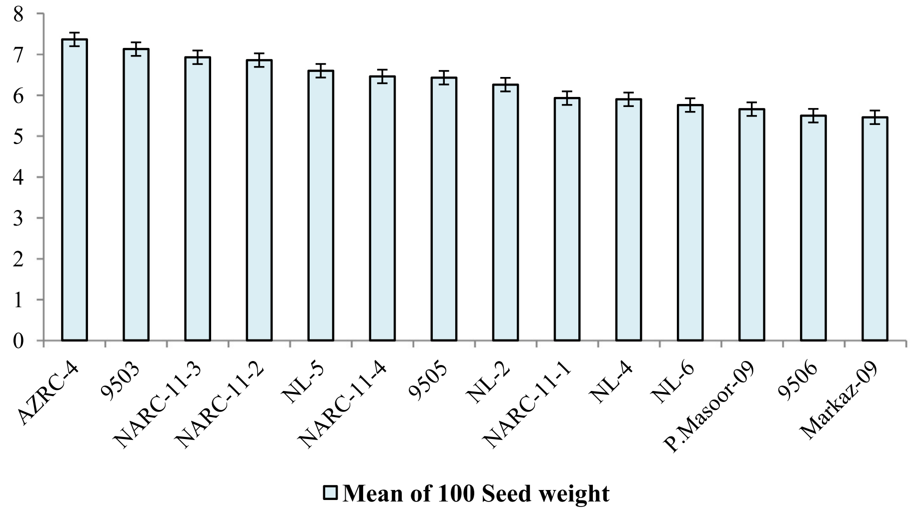

Fig. 9. Weight of 100 seeds of fourteen genotypes of the present research work.

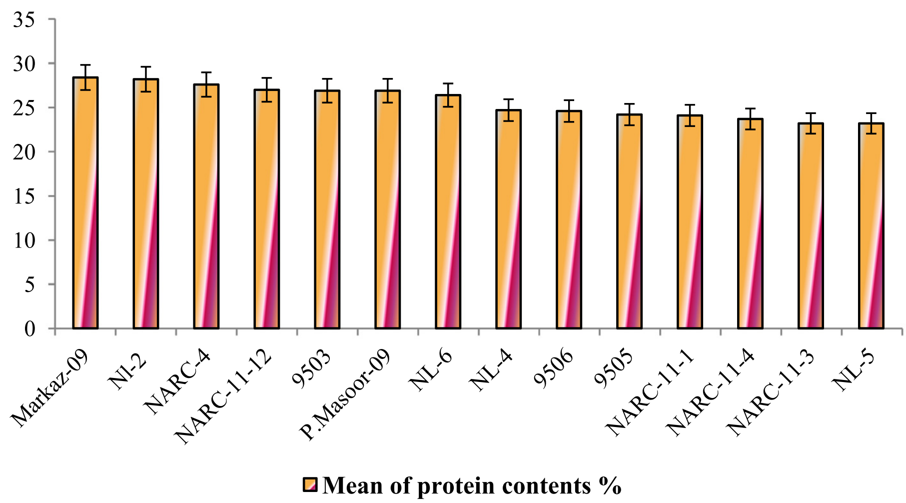

Fig. 10. Protein Contents of the 14 genotypes of lentil species.

4. Discussion

The preliminary results of present study show maximum number of days (7) were recorded for genotypes NL-2, NARC-11-1 and 09503, whereas minimum number of days (6) to 50% germination were recorded for all the remaining genotypes. Similarly (Talaka et al., 2013) also reported considerable variation in days to 50% germination in concerning lentil genotypes. Regarding to 50 percent flowering day's data ranged from 110 to 116 days. The maximum numbers of days (116.33) were shown by genotypes NARC-11-1 and minimum number (110) by genotypes NL-6. Like our findings (Wang et al., 2010) also reported the appropriate thing of flowering is a pivotal adaptive quality of controlling the circulation and survival of a plant species. Significant genetic variability in flowering period of lentil genotypes has also been reported by some earlier scientist like (Bakhsh et al., 1993; Ayub et al., 2001; Bicer and Şakar, 2004; Yaqoob et al., 2005a, 2005b).

It is cleared from the data that noteworthy difference exists among lentil genotypes regarding biological yield. Maximum biological yield (9777 kg ha^{-1}) were produced by genotypes 09503 followed by Markaz-09 (9555 kg ha^{-1}) while minimum (5333 kg ha^{-1}) was obtained from genotype NL-2. Overall biomass production was considered for economically important performance of a crop plant. On sun dried growth basis biological yield is measured as a result of ecological condition and nutrient uptake by the plants. The difference of yield was due to genetic variation among the genotypes studied. (Tyagi and Khan, 2010) concluded that pods per plant are the most important character which are responsible for treatment of seed yield in lentil.

The genotypes AZRC-4 revealed highest grain yield (3655.6 kg/ha) followed by genotypes 09506 (3455.6 kg ha^{-1}). Whereas minimum grain yields was obtained from genotype P.Masoor-09. It is also resulted that grain yield is affected by many agronomic condition and environmental factors. It depends upon on single yield components. Our result are same as result of (Ayub et al., 2001; Mandal and Majumdar, 2001; Reddy and Ahlawat, 2001; Bicer and Şakar, 2004; Yaqoob et al., 2005a, 2005b; Tyagi and Khan, 2010; Dutamo et al., 2015) who investigated that differences in the seed yield ha^{-1} due to change in genetic material.

In current study 100 seed weight in various lentil genotypes were significantly affected and rang from 5.4 to 7.3 g. The heaviest seed 7.3 g per 100 grain were produced by genotype AZRC-4 followed by 09503 7.1 g, whereas the lowest weight were reported from genotype markaz-09 5.4 g. For the final crop yield, seed weight is essential factor for determination. The difference of seed weight of genotypes under observation was take place due to different genetic potential of genotypes for character. Size and weight of seed is important feature which directly correlates with final grain yield. The selection criterion on the basis of seed size varies from crop to crop.

The size of grain always differs under different soil moisture regimes and nutrient availability to crop. The present study can be compared with (Bakhsh et al., 1993; Kayan and Olgun, 2012; Roy et al., 2013) that studied large variation among seed weight and larger seed size do not need to produce more yield.

The Markaz-09 has more amount of protein contents in their seed (28.45%) followed by genotypes NL-2 (28.24%), while low protein contents were observed from genotype NL-5 (23.21%) respectively. Varieties have significantly different protein contents that are highest protein content in BARI Masur-4 (25.80%), BARI Masur-3 (25.50%), BARI Masur-2 (28.31%). According to (Khatun et al., 2010) they also concluded that seed present on lower plant parts had greater protein content as compare to middle and upper part of plant.

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References

Ahmad, Z., Khan, S.M., Ali, S., Rahman, I.U., Ara, H., Noreen, I., Khan, A., 2016. Indicator species analyses of weed communities of maize crop in district Mardan, Pakistan. Pak. J. Weed Sci. Res. 22, 227–238.

Aman, U., Hatam, M., 2000. Grain yield potential of lentil germplasm. Pak. J. Bio Sci. 3, 1553–1555 http://docsdrive.com/pdfs/ansinet/pjbs/2000/1553-1555.pdf.

Ayub, K., Hashmi, N.I., Khan, A., 2001. Performance of exotic lentil varieties under rainfed conditions in Mingora (NWFP). Pakistan Online J. Bio. Sci. 1, 343–344.

Bakhsh, A., Ghafoor, A., Malik, B.A., 1993. Genetic variability and correlation in lentil. Pak. J. Agr. Res. 14, 246–250.

Bhatty, R.S., Wu, K.K., 1974. Determination of gross energy of cereals and legumes with a ballistic bomb calorimeter. Can. J. Plant Sci. 54, 439–441.

Bibi, S., Khan, S.M., Rehman, A., Rahman, I.U., Ijaz, F., Sohail, A.Afzal, Khan, R., 2016. The effect of Potassium on growth and yield of strawberry (Fragaria ananassa (Duchesne ex Weston) Duchesne ex Rozier). Pak. J. Bot. 48 (4), 1407–1413 https://www.pakbs.org/pjbot/PDFs/48(4)/12.pdf.

Bicer, B.T., Şakar, D., 2004. Evaluation of some lentil genotypes at different locations in Turkey. Int. J. Agri. Biol. 6, 317–320.

Conley, D.J., Paerl, H.W., Howarth, R.W., Boesch, D.F., Seitzinger, S.P., Karl, E., Lancelot, C., Gene, E., Gene, E., 2009. Controlling eutrophication: nitrogen and phosphorus. Science 123, 1014–1015.

Dutamo, D., Alamerew, S., Eticha, F., Assefa, E., 2015. Genetic variability in bread wheat (*Triticum aestivum* L.) germplasm for yield and yield component traits. J. Biol. Agric. Healthc. 5, 140–147.

Erskine, W., Saxena, M.C. (Eds.), 1993. Proceedings of the Lentil in South Asia.

Gan, Y.T., Zentner, R.P., McDonald, C.L., Warkentin, T.D., Vandenberg, A., 2009. Adaptability of chickpea in northern high latitude areas-Maturity responses. Agr. Forest. Meteorol. 149, 711–720.

Hariyappa, N., 2006. Effect of phosphorus and sulphur on growth, yield and quality parameters of onion (Allium cepa L.). M.Sc. (Agri.) Thesis, Uni. Agr. Sci., Dharwad, India.

Iqbal, M., Khan, S., Khan, M.A., Ur Rahman, I., Abbas, Z., 2015. Exploration and inventorying of weeds in wheat crop of the district Malakand, Pakistan. Pak. J. Weed Sci. Res. 21, 435–452.

Kayan, N., Olgun, M., 2012. Evaluation of Yield and Some Yield Components in Lentil (*Lens culinaris* Medik.). Int. J. Agr. 2, 834–843.

Khan, S.M., Page, S., Ahmad, H., Harer, D., 2014. Ethno-ecological importance of plant biodiversity in mountain ecosystem with special emphasis on indicator species of a himalayan valley in the northern Pakistan. Ecol. Indic 37, 175–185.

Khan, W., Khan, S.M., Ahmad, H., Ahmad, Z., Page, S., 2016. Vegetation mapping and multivariate approach to indicator species of a forest ecosystem: a case study from the Thandiani sub Forests Division (TsFD) in the Western Himalayas. Ecol. Indic 71, 336–351.

Khan, S.M., 2012. Plant communities and vegetation ecosystem services in the Naran Valley, Western Himalaya (Doctoral dissertation, University of Leicester).

Khatun, A.M., Bhuiyan, A.H., Dey, T.K., 2010. Nitrogen uptake and protein yield in lentil as influenced by seed collection from different parts of plants Bangladesh. J. Agril. Res. 35, 515–523.

Mahmood, I., Razzaq, A., Bukhari, S.A.H., Naveed, T.M., 2010. Optimization of Lentil (Lens culinaris Medic.) Cultivars response to NPK under rainfed conditions. J. Agr. Res. 48, 343–351.

Mandal, K.G., Majumdar, D.K., 2001. Agro-physiological characteristics of Lentil in relation to irrigation, nitrogen and plant density. J. Interacad. 5, 156–161.

Menalled, F., 2015. Lentil underground—renegade farmers and the future of food in America, by liz carlisle: gotham books, penguin group, USA. Agroecol. Sust. Food 39, 1172–1174.

Reddy, S.V.K., Ahlawat, I.P.S., 2001. Dry matter accumulation and nutrient uptake in lentil in relation to cultivar, phosphorus, zinc and biofertilizer. Res. Crops. 2, 21–24 https://eurekamag.com/research/003/410/003410982.php.

Roy, S., Islam, M.A., Sarker, A., Malek, M.A., Rafii, M.Y., Ismail, M.R., 2013. Determination of genetic diversity in lentil germplasm based on quantitative traits. Aus. J. Crop Sci. 7, 14–21.

Rozan, P., Kuo, Y.H., Lambein, F., 2001. Amino acids in seeds and seedlings of the genus Lens. Phytochemistry 58, 281–289.

Sabaghnia, N., Dehghani, H., Sabaghpour, S.H., 2008. Graphic analysis of genotype by environment interaction for lentil yield in Iran. Agron. J. 100, 760–764.

Sadiq, M.S., Sarwar, G., Saleem, M., 2001. Genotype x environment interactions for seed yield in lentil (*Lens culinaris* Medik). J. Agric. Res. 39, 119–124.

Sahi, S.T., Randhawa, M.A., Sarwar, N., Khan, S.M., 2000. Biochemical basis of resistance in lentil (*Lens culinaris* Medik) against ascochyta blight: I. Phenols. Pak. J. Bio. Sci. 3, 1141–1143.

Seline, K.G., Johein, H., 2007. The determination of L-carnitine in several food samples. Food Chem. 105, 793–804.

Sharma, R.C., Banik, P., 2015. Baby corn-legumes intercropping systems: I. Yields, resource utilization efficiency, and soil health. Agroecol. Sust. Food 39, 41–61.

Talaka, A., Rajab, Y.S., Mustapha, A.B., 2013. Growth performance of five varieties of soybean (*Glycine max*. [L.] Merill) under rainfed condition in Bali local government area of Taraba State-Niger. 2: pp. 5–8. <http://www.iosrjournals.org/iosr-javs/papers/vol2-issue4/B0240508.pdf?id=1836>.

Tyagi, S.D., Khan, M.H., 2010. Studies on genetic variability and interrelationship among the different traits in Microsperma lentil (*Lens culinaris* Medik). J. Agric. Biotech. Sustain. Dev. 2, 15–20.

Wang, X., Shen, J., Liao, H., 2010. Acquisition or utilization, which is more critical for enhancing phosphorus efficiency in modern crops? Plant Sci. 179, 302–306. http://dx.doi.org/10.1016/j.plantsci.2010.06.007.

Whitehead, S.J., Summerfield, R.J., Muehlbauer, F.J., Coyne, C.J., Ellis, R.H., Wheeler, T.R., 2000. Crop improvement and the accumulation and partitioning of biomass and Nitrogen in lentil. Crop Sci. 40, 110–120.

Yaqoob, M., Mansoor, M., Najibullah, Din, N., 2005a. Ratta Kulachi-2004- A high yielding lentil cultivar for rainfed ecologies of NWFP. Ind. J. Pla. Sci. 4, 244–349.

Yaqoob, M., Nasiruddin, Mansoor, M., Najibullah, qoob et al., 2005 b. A new lentil (*Lens culinaris*) cultivar for southern districts of NWFP. Indus J. Pl. Sci. 4, 314–331.