Journal of Agriculture Sustainability and Environment ISSN:2997-271X
https://doi.org/10.56556/jase.v1i1.882

RESEARCH ARTICLE

Response of maize productivity to nitrogen management and mulching practices

Mubassir Ahmad[1*], Muhammad Ibrahim[2], Amjad Ali[3], Inzimam Hussain[2], Naveed Ul Haq[1], Imad Ali[1], Diyan Ahmad[1]

[1]Department of Agriculture, University of Haripur, Pakistan
[2]Department of Agriculture, University of Swabi, Khyber Pakhtunkhwa, Pakistan
[3]Agriculture Research Station (ARS) Swabi,Khyber Pakhtunkhwa, Pakistan

Corresponding Author: Mubassir Ahmad; mubassirbachai1997@gmail.com
Received: 12 February, 2022, Accepted: 13 May, 2022, Published: 19 May, 2022

Abstract
The present experiment was conducted to evaluate the effect of different nitrogen levels and mulch practice on days to physiological maturity, plant height, mean leaf area, mean weeds population, weeds fresh weight, weeds dry weight of maize at Agriculture Research Station Swabi, Khyber Pakhtunkhwa during summer 2019. The experiment was laid out in a randomized complete block design (RCBD) with three replicates. Data was recorded on six quantitative traits i.e. days to physiological maturity, plant height, mean leaf area, mean weeds population, weeds fresh weight, weeds dry weight. Results indicated that Days to physiological maturity, plant height, mean leaf area, mean weeds population, weeds fresh weight, weeds dry weight was significantly altered due to applied treatment. The treatment nitrogen level (N4-150 g.) give high results for the Days to physiological maturity, plant height, mean leaf area, mean weeds population, weeds fresh weight, weeds dry weight as compared to other level of nitrogen, (N1-control), (N2-50g), (N3-100g), (N5-200g). And similarly organic mulch (crop residue) show high result for the Days to physiological maturity, plant height, mean leaf area, mean weeds population, weeds fresh weight, weeds dry weight as compared to inorganic mulch (plastic mulch). It was observed that the nitrogen level (N4-150g) valuable fertilizer and organic mulch show better result as compare to other nitrogen level and inorganic mulch.

Keywords: Organic mulch; Maize; Nitrogen fertilizer

Introduction

Maize (Zea mays L.) belongs to Phocaea and is grown in both spring and summer seasons in Pakistan. It is among the high yielding crops and has great economic importance for the developing countries like Pakistan where human population is continuously increasing. In Pakistan, maize is the third important cereal crop after wheat and rice (PARC, 2007). The area under maize cultivation in Pakistan and Khyber Pakhtunkhwa Province was 935.1 K and 421.9 K ha, respectively with production of 3261.5 K tones and 752.2 K tones and the average grain yields of 3488 and 1135 kg ha-1 in Pakistan and Khyber Pakhtunkhwa, respectively (MINFAL, 2010). Khyber Pakhtunkhwa and Punjab contributes 68% and 30% of the total production, while Sindh and Balochistan contributes a very a small percentage i.e. 2-3% (Anonymous, 2010).

Maize crop is planted more than 500,000 ha land area in high mountain and plains of Khyber Pakhtunkhwa but its production is much lower in these areas (Rahman et al., 2012). Maize grains have great economic importance and are used for food, fodder, pharmaceutical and industrial purposes. Its grains contain starch, protein, fiber, oil and ash (Ahmad et al., 2007).

The most evident and alarming issue of the current time, Global Climate Change is now arising as a major threat to the world food security as it has severely affected crop growth and development through various climatological events i.e. drought, flood, high temperature etc. maize crop is very sensitive to these hazards in its critical growth stagesResearchers are using various effective technologies to overcome these hazards. Among different technologies mulches i.e. organic mulches, are considered to have profitable role in combating these hazardous Rasoul Fakhari et al. (2018)

Mulching is one of the simplest and most beneficial practices you can use in the garden. Mulch is simply a protective layer of material that is deposited on the ground. Mulches can be organic - such as blades of grass, straw, bark chips and other similar materials - or inorganic - such as stones, brick chips and plastic. Organic and inorganic mulches have many advantages.Mulching is one of the management practices aimed at increasing water conservation and effectively controlling weed infestation in field crops (Ram et al., 2013). Organic mulches perform additional functions, such as increasing soil organic matter content, improving biological activity (Zhao et al., 2012), improving soil structure, and improving soil quality. Increase in plant nutrients after decomposition (Depar et al., 2016). Alternative methods of weed control, such as mulching, are often used in place of herbicides. Mulching is a popular weed control method that has been used successfully in many countries (Amoghein, et al., 2013). Mulch has positive effects on soil and plants, that is, improves the soil environment, moderates its temperature (Anikwe et al., 2007), increases soil porosity (Shaxson et al. Barber, 2016), optimizes the rate of water infiltration during heavy rains (Bu et al., 2013), controls runoff anderosion, suppresses weed growth and preserves soil moisture content (Depar et al., 2016).Depending on the type of mulch material used, mulching preserves soil water, reduce soil temperature and consequently promotes seedling establishment and increases the seedling survival under extreme conditions mainly by reducing the soil surface exposure to direct solar radiation (Murungu et al., 2011; Benigno et al., 2012; Woods et al., 2012). Mulches spread on soil surfaces lower average soil temperature during the hot season, thus keeping the temperature in the regular range during the growing season (Blazewicz-Wozniak, 2010). Another type or inorganic mulch is pebbles they do not rot and so are used on decorative flowerbeds. As they do not rot from year to year, it is difficult to add new plants as the pebbles must be moved. Therefore, it is burdensome to plant new crops, as the pebbles must be shifted and rearranged (Maggard et al., 2012).This is an important factor for the unstable mid-range climate, in which the summer is typically short. Also, film mulching reduces the evaporation of moisture, making the soil cooler on hot days. Thus, the black plastic film allows plants to better grow in the heat, in the cold, and in times of drought. This film prevents the growth of weeds in the soil (Kasirajan&Ngouajio, 2012)

Plastic film mulch, increased plant densities and chemical fertilizer input have been extensively used in intensive agricultural production areas (Bu et al., 2013;Liu et al., 2014).The mulching techniques had greater role for moisture conservation whereas N management had proven to improve soil fertility and crop production. However, research gap still exist to quantify their effects on maize crop stand and phonological occurrence. Therefore, the present field experiment was conducted to find out the effect of N management treatments under mulching practices in maize crop.

Mineral nitrogen nutrition is one of the most significant factors with its influence on productivity and features of plants. Optimal nitrogen nutrition has an influence on a development of the root system and over ground biomass as well as on nutritive value of fruits (Glamočlija, 2004; Glamočlija et al., 2015; 2017; Đekić et al., 2014; 2015; Terzić et al., 2018; Božović et al., 2018a; 2018b). Fertilizer N applied to crop is subjected to many chances; a

portion of the N will remain in the soil, some may be lost to the air, surface water, and/or ground water (Jat et al., 2013). The application of nitrogen in the quantities that surpass the needs of plants, leads to the increase of the level of nitrates in soil and their washing off into underground waters(Glamočlijaet al., 2015; 2017).

Keeping in view the above importance the objective of my study was planned to

1. To find out anappropriate mulching technique for maize productivity.
2. To find out optimum level of nitrogen for higher yield and yield components of maize.
3. To find out the interactions among mulching practices and nitrogen levels.

Materials and Methods

Present experiment was conducted in the Agriculture Research Station, Swabi during summer, 2019. Some of the basic materials that are used with specialized methods during this experiment are discussed as follows;

Materials

Major material used during this experiment are; maize seed (Jalal), fertilizer (urea) as nitrogen source, (N1control), (N2.50g), (N3.100g), (N4.150g), (N5.200g), FYM, Organic mulch (crop residue) and Inorganic mulch (plastic).

Methods

Some basic methods followed during this experiment are as follows;

Field Preparation

In order to make the field suitable for the experimental process field was ploughed two times before the sowing. After proper ploughing the field was planked for proper leveling and to suppress the huge clods in order to ensure the equal supply of water and nutrients.

Layout

As the field was properly leveled then RCBD design was constructed in the field. After layout designing different treatment i.e. various nitrogen levels and mulches were assigned to the specific plots in order to check the maize response toward these treatments.

Sowing and data Collection

After complete seed bed preparation sowing is done with seed planter, maintaining proper row to row and plant to plant distance. As the seeds were germinated, the 1st irrigation is applied to the field and then at various stages data is recorded for the below mentioned parameters.

Plant height (cm): Plant height for all the treatments in each replication were measured with the help of a measuring tape from the base to tip of the five randomly selected plants and then average plant height was calculated.

Leaf area plant-^{1} (cm^{2}): Leaf area plant^{-1} was calculated by measuring the length and width of all leaves of the five randomly selected plants from each plot and then average was worked out to calculate the leaf area plant^{-1} by using the following formula:
Leaf area plant^{-1} = Leaf length x leaf width x Correction Factor

Weed biomass: Weed biomass was recorded with the help of tetrad. the tetrad was thrown randomly at three different places in each sub plots, and the weeds was harvested and averaged.
Fresh weeds weight: After harvesting the weeds was cleaned from soil and weighted with the help of weight balance.
Dry weeds weight: The weeds was dried in an own for 24 hours. And then weight with the help of weight balance.
Days to physiological maturity: Days to maturity was obtained by observing the sub plot when it reached to 70 % mature. The maturity is complete if the grain tip become black.

Statistical data analysis

The recorded data was arranged properly in excel and then after proper arrangement it was analyzed while using the Statistic 8.1 software. As the data was analyzed it was presented in the tables for convenience of readers.

Results andDiscussion

The current experiment was conducted in order to find out the effects of mulching and different nitrogen levels application over maize crop in district Swabi. The whole results are discussed in the tables below.

Weeds population

Data regarding weed population is presented in Table.1. Statistical analysis of the data indicated that weed population was none significantly affected by different mulching practices. According to the results more number of weeds (209.33g) was observed in M2 (organic mulching) while less number of weeds (193.33g) was noted in M1 (inorganic mulching). The possible reason for low weeding in plastic mulch may be the deficiency of photosynthesis due to the obstacle in sunlight. Our results are in line with Saeed et al. (2013) who also noted that plastic mulching reduces weed population. On the other hand, various N levels significantly affected weeds population in maize crop. According to data maximum number of weeds was noted in N1 (315.00g) followed by N2 (240.00g), N3 (178.33g) and N5 (171.67g) while less number of weeds was recorded in N4 (101.67g). Higher population of weeds in N1 may be due to the low competition for sunlight, water and air. Our results are in conformity with Blumenthal et al. (2008) who also noted that controlled treatments resulted in reduced weed population as compare to other N levels.

Weed fresh weight

Data regarding weed fresh weight is presented in Table.1. Statistical analysis of the data indicated that weed fresh weight was none significantly affected by different mulching practices. According to the results maximum fresh weight (186.33g) was observed in M2 (organic mulching) while minimum fresh weight (144.00g) was noted in M1 (inorganic mulching). The possible reason for low weeding in plastic mulch may be the deficiency of photosynthesis due to the obstacle in sunlight. Our results are in line withAli et al. (2016) who also noted that plastic mulching reduces weed population. On the other hand, various N levels significantly affected weed fresh weight in maize crop. According to the data maximum fresh weight of weeds was noted in N5 (250.00g) followed by N4 (206.67g), N1 (144.17g) and N3 (140.83g) while lowest fresh weight of weeds was recorded in N2 (84.17g). Maximum fresh weight of weeds in N5 may be due the higher level of nitrogen. Our results are in conformity with Jiang et al. (2019) who also noted that higher N levels results in number weeds and weed biomass.

Weed dry weight

Data regarding weed dry weight is presented in Table.1. Statistical analysis of the data indicated that weed dry weight was none significantly affected by different mulching practices. According to the results maximum dry weight (17.2g) was observed in M2 (organic mulching) while minimum dry weight (16.433g) was noted in M1 (inorganic mulching). The possible reason for low weeding in plastic mulch may be the deficiency of photosynthesis due to the obstacle in sunlight. Our results are in line with Zamir1 et al. (2014) who also noted that plastic mulching reduces weed population. On the other hand, various N levels significantly affected weed dry weight in maize crop. According to the data maximum dry weight of weeds was noted in N5 (22.16g) followed by N4 (17.83g), N3 (17.08g) and N1 (15.16g) while lowest dry weight of weeds was recorded in N2 (11.83g). Maximum dry weight of weeds in N5 may be due the higher level of nitrogen. Our results are in conformity with Hejazi et al. (2014) who also noted that higher N levels results in number weeds and weed biomass

Days to maturity

Data regarding days to maturity is presented in Table.2. Statistical analysis of the data indicated that Days to maturity was none significantly affected by different mulching practices. According to the results early maturity (87.067) was observed in M1 (inorganic mulching) while late maturity (85.33) was noted in M2 (organic mulching). The possible reason for late maturity in M2 may be the presence of more nutrients due plant residues. Our results are in line with Ampofo (2018) who also noted that organic mulching resulted in late maturity. On the other hand, various N levels significantly affected days to maturity in maize crop. According to the data early maturity (76.83) was observed in N1 followed by N3 (87.167), N2 and N5 (88.167) while late maturity was noted in N4 (90.66). late maturity in N4 may be due to the presence of more nitrogen Our results are in conformity with Shahzad et al (2015) who also noted that higher N levels results in late maturity in maize.

Plant height

Data regarding plant height is presented in Table 2. Statistical analysis of the data indicated that plant height was none significantly affected by different mulching practices. According to the results maximum plant height (506.7cm) was observed in M2 (organic mulching) while minimum plant height (470.3cm) was noted in M1

(inorganic mulching). The possible reason for the maximum plant height in M2 may be the presence of more nutrients due plant residues. Our results are in line with Zamir et al (2014) who also noted that organic mulching resulted in maximum plant height. On the other hand, various N levels significantly affected plant height in maize crop.

According to the data maximum plant height (631.0cm) was observed in N4 followed by N2 (503.7cm), N5 (487.88cm) and N3 (471.4cm) while minimum plant height was noted in N1 (347.4cm). Maximum plant height in N4 may be due to the higher levels of nitrogen.Results are in conformity with Šarčević et al. (2018) who also noted that higher N levels results in tallest plants.

Mulching	Weeds population	Weeds fresh weight	Dry weight
M1	193.33 a	144.00 a	16.433 a
M2	209.33 a	186.33 a	17.200 a
N Levels			
N1	315.00 a	144.17 b	15.167 bc
N2	240.00 ab	84.176 b	11.833 c
N3	178.33 bc	140.83 b	17.083 b
N4	101.67 c	206.67 a	17.833 ab
N5	171.67 bc	250.00 a	22.167 a

Table1 weeds population, weeds fresh weight, weeds dry weight.

Table 2 Days to maturity, plant height, leaf area

Mulching	Days to maturity	Plant height	Leaf area
M1	87.1 a	470.3 a	1637.3 a
M2	85.3 b	506.7 a	1689.3 a
N Levels			
N1	76.8 b	347.7 c	966.7 b
N2	88.2 a	503.9 ab	2176.7 a
N3	87.2 a	471.4 bc	1860.0 a
N4	90.3 a	631.0 a	1975.0 a
N5	88.2 a	488.9 bc	1383.3 b

Mean values of the same category followed by different letters are significant at $P \leq 0.05$ level.

Mean leaf area

Data regarding mean leaf area is presented in Table.2. Statistical analysis of the data indicated that leaf area was none significantly affected by different mulching practices. According to the results maximum leaf area ($1689.3m^2$) was observed in M2 (organic mulching) while minimum leaf area ($1637.3m^2$) was noted in M1 (inorganic mulching). The possible reason for the maximum leaf area in M2 may be the availability of organic and inorganic plant nutrients. Our results are in line with Abdullah et al(2016) who also noted that organic

mulching resulted in maximum leaf area. On the other hand, various N levels significantly affected mean leaf area in maize crop. According to the data maximum leaf area (2176.7m^2) was observed in N2 followed by N4 (1975.0m^2), N3 (1860.0m^2) and N5 (1383.3m^2) while minimum leaf area was noted in N1 (966.7m^2). The possible reason for maximum leaf area in N2 may be the availability of enough plant nutrients. Our results are in conformity with Šarčević et al. (2018) who also noted that various N levels significantly affected mean leaf area in maize crop.

Conclusion

Results revealed that mulch practice (organic and inorganic) have none significant effect on weeds population, weeds fresh weight, weeds dry weight, plant height, and mean leaf area. While mulch practice (organic and inorganic) significant effect on days to maturity

Results revealed that application of different nitrogen levels have significant effect on weeds population, weeds fresh weight, weeds dry weight,maturity, plant height, and mean leaf area. Based on the results and consequences attained from this research work, it is determined that mulch practice has significant effect on days to maturity and showed maximum value (87.067) and minimum value (85.333).Application of different nitrogen levels showed minimum values for N1 (control), and maximum values for N4 (150 g).Application of nitrogen level N4 (150 g) showed maximum values for weeds population, fresh weight, dry weight, days to maturity, plant height, mean leaf area.

Declaration

Acknowledgment: N/A

Funding: N/A

Conflict of interest: N/A

Authors contribution: N/A

Data availability: From the authors

References

Abdullahi, S., Ghosh, G., &Dawson, J. (2016). Effect of different weed control methods on growth and yield of maize (*Zea Mays* L.) under rain-fed condition in Allahabad. *Journal of Agriculture and Veterinary Science*, 9(4), 44-47.

Adhikari, P., Baral, B. R., &Shrestha, J. (2016). Maize response to time of nitrogen application and planting seasons. *Journal of Maize Research and Development*, 2(1), 83-93.

Adnan, M., Fahad, S., Iqbal, S., Arshad, M., Muhammad, D., Wahid, F., &Noor, M.N. (2018). 12. Integrated application of phosphorus (P) and phosphate solubilizing bacteria (PSB) improve maize yield. *Pure and Applied Biology*, 7(2), 494-499.

Ahmad, M., Ahmad, R., & Rehman, A. (2007). Crowding stress tolerance in maize hybrids. Economic and Business Rev., The Daily Dawn, Lahore, Pakistan, (3), 17-22.

Ali, A.B.B., A.S., Khan, M.A., Saleem, A. S. H. I. Q., Marwat, K. B., Jan, A. U., Jan, D. A. W. O. O. D., &Sattar, S. H. A. H. I. D. (2016). Performance and economics of growing maize under organic and inorganic fertilization and weed management. *Pak. J. Bot*,, 48(1), 311-318.

Ampofo, E. A. (2018). Influence of Organic Mulches on Soil Physico-Chemical Properties and Maize (*Zea Mays* L.) Crop Performance. *Journal of Agricultural Studies*, 6(2), 1-16.

Anonymous. 2010. Losses caused by weeds in major crops of NWFP. Plant Physiology Section, ARI, Tarnab, Peshawar-Pakistan.

Benigno, S.M., Dixon, K. W., & Stevens, J.C. (2013). Increasing soil water retention with native-sourced mulch improves seedling establishment in postmine Mediterranean sandy soils. Restoration Ecology, 21(5), 617-626.

Bhatt, R.,&Khera, K. L. (2006). Effect of tillage and mode of straw mulch application on soil erosion in the submontaneous tract of Punjab, India. *Soil and Tillage Research,* 88(1-2), 107-115.

Bilalis, D., Sidiras, N., Economou, G., &Vakali, C. (2003). Effect of different levels of wheat straw soil surface coverage on weed flora in Vicia faba crops. *Journal of Agronomy and Crop Science,* 189(4), 233-241.

Błażewicz-Woźniak, M.(2010). Effect of soil and plant covering and sowing time on the yield of fennel bulbs grown from sowing directly in the field. *Folia Horticulturae,* 22(2), 59-66.

Blumenthal, J. M., Baltensperger, D. D., Cassman, K. G., Mason, S. C.,& Pavlista, A. D. (2008). Importance and effect of nitrogen on crop quality and health. In Nitrogen in the Environment (pp. 51-70). Academic Press.

Dlamini, S. M. (1990). Analysis of small scale farmers' incremental technology adoption behavior in Swaziland (No. Look under author name. CIMMYT.).

Đukić, D., Jemcev, V., &Kuzmanova, J. (2007). Biotechnology of Soil, Budućnost, Novi Sad.

El Zubair, R. M., Fadlalla, B., Hussien, A. H. M., Abdelkreim, M. (2015). Effect of different nitrogen fertilization levels on yield of maize (Zea mays L.) as winter forage. Int J Sci Technol Res, 4, 197-201.

Fakhari, R., Tobeh, A., Sharifi Ziveh, P., Didehbaz Moghanlo, G., &Tahmasbi, K. B. (2018). Effects of Cover crop residue management on corn yield and weed control. *Journal of research in weed science,* 1, 7-17.

Fazlullah, M. A., Fahad, S., Iqbal, S., Arshad, M., Muhammad, D., Wahid, F., &Noor, M. (2018). Integrated application of phosphorus (p) and phosphate solubilizing bacteria (psb) improve maize yield. Pure and Applied Biology.

Glamočlija, Đ., Đurić, N., & Glamočlija, N. (2017). Tritikale, origin, significance, technology of production and preservation of products. Monograph, Belgrade, 1-267.

Government of Pakistan (1980). Agricultural statistics of Pakistan.

Hashim, S., Marwat, K. B., Saeed, M., Haroon, M., Waqas, M., & Shah, F. (2013). Developing a sustainable and eco-friendly weed management system using organic and inorganic mulching techniques. *Pakistan Journal of Botany,* 45(2), 483-486.

Hejazi, L., & Soleymani, A. (2014). Effect of different amounts of nitrogen fertilizer on grain yield of forage corn cultivars in Isfahan.

Imran, S., Arif, M., Khan, A., Khan, M. A., Shah, W., &Latif, A. (2015). Effect of nitrogen levels and plant population on yield and yield components of maize. *Advances in Crop Science and Technology,* 1-7.

Javed, A., Iqbal, M., &Farooq, M. (2018). Effect of nitrogen fertilization under plastic and straw mulched conditions on crop yield and water use efficiency in maize-wheat rotation. Applied *Ecology and Environmental Research,* 16(6), 7395-7411.

Ji, S., &Unger, P. W. (2001). Soil water accumulation under different precipitation, potential evaporation, and straw mulch conditions. Soil Science Society of America Journal, 65(2), 442-448.

Jiang, C., Ren, X., Wang, H., Lu, D., Zu, C., &Wang, S. (2019). Optimal Nitrogen Application Rates of One-Time Root Zone Fertilization and the Effect of Reducing Nitrogen Application on Summer Maize. *Sustainability*,11(10), 2979.

Kambal, A. E. (1983). Comparative performance of some varieties of sorghum, maize and pearl millet for forage production in different seasons. *Sudan Agricultural Journal*, 10, 46-60.

Kasirajan, S., &Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. *Agronomy for Sustainable Development*, 32(2), 501-529.

Khurshid, K. A. S. H. I. F., Iqbal, M., Arif, M. S., &Nawaz, A. (2006). Effect of tillage and mulch on soil physical properties and growth of maize. *International Journal of Agriculture and Biology*, 8(5), 593-596.

Lal, R., De Vleeschauwer, D., &Nganje, R. M. (1980). Changes in properties of a newly cleared tropical Alfisol as affected by mulching. *Soil Science Society of America Journal*, 44(4), 827-833.

Maggard, A. O., Will, R. E., Hennessey, T. C., McKinley, C. R., &Cole, J. C. (2012). Tree-based mulches influence soil properties and plant growth. *HortTechnology*, 22(3), 353-361.

Mahmood, N., Anees, M., Ahmad, S., &Zakaullah. (2011). Effect of mulching on vegetable production in tunnel farming. *Mycopath*, 9(1), 21-24.

Mertz, E. T., Bates, L. S., &Nelson, O. E. (1964). Mutant gene that changes protein composition and increases lysine content of maize *Endosperm. Science*, 145(3629), 279-280.

Moody, J. E., Jones Jr, J. N.,&Lillard, J. H. (1963). Influence of straw mulch on soil moisture, soil temperature and the growth of corn. *Soil Science Society of America Journal*, 27(6), 700-703.

Mtambanengwe, F., Nezomba, H., Tauro, T., Chagumaira, C., Manzeke, M. G., &Mapfumo, P. (2015). Mulching and fertilization effects on weed dynamics under conservation agriculture-based maize cropping in Zimbabwe. *Environments*, 2(3), 399-414.

Muhammad, S., Muhammad, H., Muhammad, W., Shah, F., Sadiq, A., Hamida, B. (2013). Mulching: a management practice for weeds in maize. *Pakistan Journal of Weed Science Research*, 19(4), 403-410.

Murungu, F. S., Chiduza, C., Muchaonyerwa, P., & Mnkeni, P. N. S. (2011). Mulch effects on soil moisture and nitrogen, weed growth and irrigated maize productivity in a warm-temperate climate of South Africa. Soil and Tillage Research, 112(1), 58-65.

Norwood, C. A. (2001). Dryland corn in western Kansas: Effects of hybrid maturity, planting date, and plant population. *Agronomy J*, 93(3), 540-547.

Oroka, F. O. (2016). Mulching effects and nitrogen application on the performance of Zea mays L: crop growth and nutrient accumulation. International Letters of Natural Sciences, 51.

Rahman, H. Z., Shah, S., Shah, M., Khalil, I. (2012). Evaluation of maize S2 lines in test crosses combinations II: yield and yield components. Pak J Bot, 44, 187-192.

Rajashekarappa, K. S., Basavarajappa, B. E., Puttaiah, E. T. (2014). Effect of Different Organic Mulches and in Situ Green Manuring on Soil Properties and Yield and Economics of Maize in Dryzone of Karnataka.

Saeed, M. (2009). Interference of horse purslane (Trianthema portulacastrum L.) with maize (Zea mays L.) at different densities (Doctoral dissertation, NWFP Agricultural University Peshawar-Pakistan).

Saeed, M., Haroon, M., Waqas, M., Shah, F., Sadiq, A., Bibi, H. (2013). Mulching: A management practice for weeds in maize. *Pakistan Journal of Weed Science Research*, 19(4).

Šarčević-Todosijević, L., Ljubišaživanović, V.P., Đukić, D., Mikić, S., Spalevic, V., Mačkić, K. Effects of quantity of nitrogen on maize yield. *In Book of Proceedings* (p. 45).

Schepers, J. S., Moravek, M. G., Alberts, E. E., &Frank, K. D. (1991). Maize production impacts on groundwater quality. *Journal of Environmental Quality*, 20(1), 12-16.

Sharma, R., Adhikari, P., Shrestha, J., &Acharya, B. P. (2019). Response of maize (Zea mays L.) hybrids to different levels of nitrogen. *Archives of Agriculture and Environmental Science*, 4(3), 295-299.

Sharma, T., & Gaikwad, D. S. (2018). Effect of nitrogen on different varieties of maize fodder (Zea mays) (Doctoral dissertation, *Lovely Professional University).*

Subrahmaniyan, K., & Zhou, W. (2008). Soil temperature associated with degradable, non-degradable plastic and organic mulches and their effect on biomass production, enzyme activities and seed yield of winter rapeseed (*Brassica napus L.*). *Journal of Sustainable Agriculture*, 32(4), 611-627.

Tian, G., Kang, B. T., &Brussaard, L. (1993). Mulching effect of plant residues with chemically contrasting compositions on maize growth and nutrients accumulation. *Plant and soil*, *153*, (2), 179-187.

Tolk, J. A., Howell, T. A., Evett, S. R. (1998). Evapotranspiration and yield of corn grown on three high plains soils. *Agronomy J*, 90(4), 447-454.

Unger, P. W., Jones, O. R. (1981). Effect of soil water content and a growing season straw

Villar Mir, J. M., Villar Mir, P., Stockle, C. O., Ferrer, F., & Aran, M. (2002). On-farm monitoring of soil nitrate-nitrogen in irrigated cornfields in the Ebro Valley (northeast Spain). *Agronomy J*, 94(2), 373-380.

Wienhold, B. J., Trooien, T. P., Reichman, G. A. (1995). Yield and nitrogen use efficiency of irrigated corn in the northern Great Plains. *Agronomy j*, 87(5), 842-846.

Yang, Y. M., Liu, X. J., Li, W. Q., Li, C. Z. (2006). Effect of different mulch materials on winter wheat production in desalinized soil in Heilonggang region of North China. *Journal of Zhejiang University Science B*, 7(11), 858-867

Zamir, S. I., Asif, M., Haq, I., Ashraf, U., Hussain, S., &Khan, M. K. (2014). Maize phenology, yield and its quality is affected by organic mulches and various irrigation regimes. *International Journal of Modern Agriculture*, 3(2), 56-59.