Int. Jour. of App. Sc. and Eng. (IJASE) **2**(2) : Dec 2014, 45-57

Various problems of dryland agriculture and suggested agro-techniques suitable for dryland vegetable production

M. Mudasir Magray[1], Nayeema. Jabeen[1], M.A. Chattoo[1], F.A. Parray[1] Alima. Shabir[1] and S.N. Kirmani[2]

[1]Division of Vegetable Science, Skuast Kashmir, Shalimar Srinagar-191 121
[2]Division of Fruit Sciences, Skuast Kashmir, Shalimar Srinagar - 191 121
Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir 191121.

Corresponding author:

Abstract

Due to low opportunities and higher population of landless and agricultural laborers as well as low land and labor productivity,poverty is concentrated in drier regions. The traditional subsistence farming systems have changed and at present time farmers have minute options and are are preferring to grow high value crops particularly vegetables which require intensive use of inputs, most importantly life saving irrigations, and therefore they face real problems in day to day life and is a serious concern which should be given huge importance as far as living conditions in such regions.

In every region of the world it is necessary to find or develop appropriate technologies for agriculture. And for dry land agriculture particularly.,Millions of people live in these regions,and if current trends in population increase continue, there will soon be millions more. Yet, the techniques are so varied that only a for a very large volume would cover the entire subject. Then agronomic techniques, adoption of water harvesting principles, use of resistant crop varieties that may be useful in such areas are suggested.

Different moisture conservation practices viz., ridges and furrows, ridges and furrows + mulch and farmers practice (Flat bed method) are being followed in vegetable crops. Ridge and furrows along with mulch enhanced the vigour of the vegetable crops as manifested in higher plant height, leaf area and dry matter production (Allolli et al.,2008). At present, the major arid vegetables being grown by the farmers on small scale (0.10 ha) to large scale (2.50 ha) in different cropping systems during Kharif and Rabi seasons are Citrullus lanatus, Snapmelon, Brinjal, Okra, Bottlegourd,Ridge gourds, Clusterbean, Round melon,, Tomato, Chilli, Pea, Cauliflower,Cabbage,Spinach, Fenugreek (leaves), Coriander (green), Carrot, Radish,, Green Onion, Garlic, Mustard leaves, Moringa pods, etc. (Meena et al .,2009).

Keywords: Vegetable rainfed production,Rainfed vegetables,Dryland problems techniques for rainfed Vegetable production,Watershed management.

We know that India ranks first among agricultural countries in terms of both area and value of produce. Of the world's poor, 70% live in rural areas and are mainly depended for their agricultural activities on rainfall-Sources of irrigation(Sharma *et al*., 2005). Rainfed areas of the country are spread over nearly 31.7 million hectare land area of which 41.5% is arable and 19 per cent is cultural wasteland. The Rainfed regions are found mainly in North – West and Southern part of the country. The major parts of the country under hot arid conditions are Western Rajasthan (19.62 Million ha), North-western Gujarat (6..2 M. ha), South-western Punjab (1.45 M. ha), South-western Haryana (1.28 M. ha), Andhra Pradesh (2.16 M. ha), Karnataka (0.86 M. ha), and Maharastra (0.13 M. ha) (Meena *et al* 2009). These regions of the country are characterized by hostile agro-climate and fragile eco-system. The dry land areas are characterized by an annual rainfall between 100 – 500 mm with a coefficient of variation (CV) varying from 40 – 70 per cent low and erratic rainfall combined with extremes of temperature (450-500 cal/cm2/day); low relative humidity; high potential evapo transpiration value ranging from 1600 mm in eastern part and 1800 mm in western part of the region (Yadava and Soni 2008).

Defining dry land agriculture Scientifically based on Reddy and Reddis definition,Dryland Agriculture may be classified into three groups on the basis of annual rainfall.

Dry Farming

Cultivation of crops in areas where annual rainfall is less than 750mm and crop failures due to prolonged dry spells during crop period are most common.Dry farming is practiced in arid regions with the help of moisture conservation practices.Alternate land use system is suggested in this region.

Dry land farming

Cultivation of crops in areas where annual rainfall is more than 750 mm but less than 1150mm is called Dry land farming.Dry spells may occur,but crop failures are less frequent .Higher Evapotranpiration (ET) than the total precipitation is the main reason for moisture deficit in these areas .The soil and moisture conservation measures is the key for dryland farming practices in semi-arid .regions.Drainage facility may be required especially in black soils.

Rainfed farming

Means cultivation of crops in regions where annual rainfall is more than 1150mm. There is less chances of crop failures due to dry spells.There is adequate rainfall and drainage becomes the important problem in rainfed farming.This farming is practiced in of 143humid regions.

Problems associated with dryland agriculture

In our country, irrigated area constitutes 33% and 67% is dryland and rainfed,out.8 million hectares of cultivated land.Total cropped area is 187.94 mha.Such Dryland Agricuture contributes about 44% of national food grain production.The maximum irrigated area will be achieved 50% after the full utilization of all sources of irrigation.In this way 50% cultivated area will remain unirrigated. After full exploitation of dryland ,it may contribute upto 75% of total foodgrain production (Arun Katyayan.2009).Problems of dry land agriculture are as:

Water

Water is necessary for existence of life of living organisms. Some Plants have become adopt to live and reproduce in semi arid, arid, and even desert regions. However, as aridity increases, fewer and fewer species are adapted, and the biomass is thus reduced. Plants are adapted to aridity by different mechanisms. There are plants with a short life cycle that can germinate,grow, and produce during a very short period of available moisture (Sometimes called Escape mechanisms. There are plants which have with deep or extensive root systems which have the ability to absorb from deeper areas. There are plants which store up water in their tissues and release it very slowly. There are plants that are protected from water loss by waxy coating layer. There are plants with very small or narrow leaves, thus reducing leaf area and water loss by transpiration. Water which falls in dryer regions is wasted as the amount is too small to penetrate the soil sufficiently, or it may run through a porous soil too quickly, or it may run off too quickly

Heat and Wind

The major effects of heat and wind are to increase the temperature of plant leaf surfaces and thus increase rate of evaporation of water. Wind may also cause mechanical damage to crops.The effects of winds can be reduced by windbreaks and shelter belts (lines of trees perpendicular to the direction of prevailing winds). Some useful tall species are tamarisk, casuarina, and eucalyptus. A windbreak can consist of trees and other plants of varying height. As a general rule, a windbreak is effective over an area two and a half times the height of the tree. One must remember, however, that a windbreak may have a competitive effect on crops for light, water and nutrients. Thus, the advantages of a windbreak must be weighed against the disadvantages in any particular environment..

Soils

Soils of the dryier regions mainly of tropics are highly variable,as they are in any climate. Nevetheless,it is possible to make some generalizations about such soils. The low rainfall and consequently reduced plant growth and development in these regions ,organic material is produced slowly and again because of deficit rainfall it may be broken down slowly as well. The amount of organic material in the soil, and thus the potential fertility, is likely to be low in dry land areas.There is a problem of leaching lossese of nutrients which declines soil fertility drastically.Soil salinity and alkanity is always a serious problems in the drier regions.

Disease and Pest infestations

Drier regions have sufficient infestations of disease and pest problems. However, these may often be quite different from those of wetter regions. Nematodes are often a severe problem in sandy soils. No general rules are useful, and indeed, agriculture anticipates diseases and pests, and their parasite. Unerratic and continuous rainfall is a major cause of several diseases and pest in these regions.

Suggested Dry land agriculture Technology

Water shed management

Much of the research done in rainfed agriculture in India relates to conservation of soil and rain water and drought proofing which is an ideal strategy for adaptation to climate change (Venkateswarlu *et al*., 2009). Important technologies include *in situ* moisture conservation, rainwater harvesting and recycling, efficient use of irrigation water, conservation agriculture, energy efficiency in agriculture and use of poor quality water. Watershed management is now considered an widely followed technology for development of rainfed agriculture. Watershed approach has many elements which help both in adaptation and mitigation. For example, soil and water conservation works, farm ponds, check dams etc. moderate the runoff and minimize floods during high intensity rainfall. Some of the most important adaptation and mitigation approaches with high potential are described below:

Table 1. Yield Variation pattern inWatershed (WS) and Non-Watershed (NWS) areas.

Crop	Yield (qt/ha) WS areas	Yield (qt/ha) NWS areas
1. Chilli	22.00	10.35
2. Coriander	15.25	6.70
3. Cumin	9.40	3.62
4. Cabbage	47.00	33.50
5. Tomato	117.50	84.75
6. Aonla	56.00	22.47
7. Mustard	14.23	8.45
8. Taramira	14.29	8.73
9. Chickpea	12.50	8.15

Source = Reddy *et al*., 2002

Rainwater Conservation and Harvesting

These include in-situ and ex-situ conservation of rainwater for recycling to rainfed crops. Increased ground water utilization and pumping water from deep tube wells is the largest contributor of irrigation to agriculture. If surface storage of rainwater in dug out ponds is encouraged and low lift pumps are used to lift that water for supplemental irrigation, it can reduce dependence on ground water.According to one of estimates that about 28 m ha of rainfed area in eastern and central states has the maximum potential to generate runoff of 114 billion cubic meters which can be used to provide one supplemental irrigation in about 25 m ha of rainfed area (CRIDA 2009). For storing such quantum of rainwater about 50 million farm ponds are required. This is one of the most important strategy not only to control runoff and soil loss but also contribute to climate change mitigation. Conjunctive use of surface and ground water is an important strategy to mitigate climate change. Innovative approaches in ground water sharing can also contribute to equitable distribution of water and reduced energy use in pumping.

Practices adopted in dry land areas

Increase Water Absorption

Prevent a Crust at the Soil Surface. Probably the greatest deterrent to a high rate of water absorption is the tendency for soils to puddle at the surface and form a seal or crust against water intake. The beating action of raindrops tends to break down clods and disperse the soil.

By tillage, create a rough, cloddy surface which lengthens the time necessary for the rain to break down the clods and seal the surface. For seed bed preparation in general, small seeds should have a finer, mellower bed than large seeds. After harvest, create a stubble mulch on the surface. Such material not only prevents raindrops from impinging directly on the soil, but impedes the flow of water down the slope, increasing absorption time.

Reduce the Runoff of Water

To the extent that water logging is not a problem, the runoff of water and its attendant erosion must be stopped.

1. Cropland should be as level as possible and mitigate any kind of slope in fields .
2. All tillage and plantings must run across (or perpendicular to) the slope of the land. Such ridges will impede the downward movement of water.
3. For every two feet of vertical drop or 250 feet of horizontal run, the field should either have bunds or contour strips.

Reducing the Loss of Soil Moisture

Reducing Soil Evaporation.

Water in the soil exists as a continuous film surrounding each grain. As water near the surface evaporates, water is drawn up from below to replace it, thinning the film. When it becomes too thin for plant roots to absorb, wilting occurs.

- Shelter belts of trees or shrubs reduce wind speeds and cast shadows which can reduce evaporation 10 to 30% by itself and also reduce wind erosion.
- Mulching reduces the surface speeds of wind and reduces soil temperatures.
- Shallow tilling can create a dirt mulch 2 to 3 inches deep which dries out easily but is discontinuous from the subsurface water, preventing further loss. Tillage must be repeated after each rain to restore the discontinuity.(R.Cresswall 1998).

This is most workable where rainfall occurs in a few major rainfalls with relatively long intervals in between.

Bunding

The first essential step in dry farming is bunding. The land is surveyed and level contours determined every hundred feet. For unusual slopes, it is recommended that for every fall of two feet, bund 18 to 24 inches in height be constructed. Even when land is fairly flat, a 12 inch high bund every 250 feet is still found useful (R.Cresswall 1998). Excess storm water is released by constructing periodic waste weirs with a sill of one-half bund height. This will retain water and minimize the loss of top soil.

In order to make the bunds, land must be marked by the surveyor with bund lines. A few feet on either side of it, the land should be plowed and harrowed. The bund former should be worked along the bund twice, side by side, leaving a furrow in between. This furrow in the middle should be filled in with soil from the plowed portions on both sides, by means of a scraper. The outlets or “waste weirs” should be constructed of stones.

Strip Cropping.

Strip cropping is a technique that aims to control erosion and increase water penetration in soil. Thus water becomes available for absorption by plants. Therefore soil fertility is maintained and plant crop growth response is stimulated by this technique .In effect, it employs several good farming practices such as crop rotation, contour cultivation, stubble mulching, etc. By growing in alternating strips crops that permit erosion and exposure of soil and crops that inhibit these actions, several functions are performed:.

- ❒ Erosion is prevented considerably.
- ❒ Soil fertility is maintained largely
- ❒ Movement of runoff water is blocked
- ❒ Water percolation in soil is increased

- Runoff water is desilted.
- Absorption of water by plants is increased.

Summer Fallow

All of the principles of water conservation and utilization pertaining to dry-farming will not make a crop grow if sufficient rain does not fall. Where the soil depth exceeds 18 inches (450 mm), however, it has been shown that it is possible to store water as soil moisture from one year to the next by the use of proper summer fallow techniques. With a soil depth of 10 to 15 feet, up to 75% of the incident water may be retained though 20% to 40% is more normal (R.Cresswall 1998). Thus, in an area that averages sufficient rainfall for crop growth, it will be rare that the sum of the stored water and incident water will not be sufficient for crop production. Where families in India have faithfully set aside 5 to 6 acres for summer fallow each year, drought-induced famine has been virtually eliminated.

Reducing Transpiration.

All growing plants extract water from the soil and evaporate it from their leaves and stems in a process known as transpiration. Weeds compete not only for soil nutrients, but also for water and their control is unevitable. Selection of crop is critical in these areas. Only those crops should be planted which have mechanisms to minimise effects of drought stress in such areas. Some crop varieties have smaller number of leaves, lesser leaf surface, fewer stomato, stomato, remaining closed during stresses and some plants like corn, curl their leaves during hot afternoon and open them at night, effectively reducing their water loss .Some plants have become resistant to drought stress by secretion of waxy coatings on their leaves. In dry farming areas, the number and spacing of plants is reduced so that fewer plants compete for soil moisture,soil nutrients and solar light.

Dry Farming Practices

Dry farming practices is package of techniques carried out in the light of the oncoming significant droughts to reduce effects of stresses occurring as a result of dry climates. The following packages of agriculture techniques are discussed as follows.

Mulches

This technology is very simple in application and have huge benefits but still suffering from short comings. Water enters easily in porous soil and, as it movess downward, becomes absorbed as films of water around the soil grains. These films form a continuous column of water to the surface of the soil. The film tends to remain the same thickness around all the soil grains with which it is in contact. This film of water in the soil is known as the capillary water and is only the source of water for the plants.

The sun, wind, and dry air will cause evaporation at the surface, thus reducing the thickness of the film at the surface. The thicker films in the subsoil will rise to equalize the distribution again. This will continue until the films are so thin that the plant roots can draw no further moisture from them. The result is drought.

Now we can suggest to farmers in these areas to adopt stubble mulching. Stubble mulching aims at disrupting the soil drying process by protecting the soil surface at all times, either with a growing crop or with crop residues such as leaves,stem parts or any other plant parts (stubble) left on the surface during fallows. To be effective, at least one ton per hectare must cover the surface, and the maximum benefit per unit residue is obtained at about two tons per hectare. Benefit may still be obtained at 8 tons per hectare.

The first benefit of a stubble mulch is that wind speed is reduced at the surface by up to 99%, significantly reducing losses by evaporation. In addition, crop and weed residues can improve water penetration and decrease water runoff losses by a factor of 2 to 6 times and reduce wind and water erosion by a factors of 4 to 8 relative to a bare fallow field. Several researchers have revealed beneficial effect on mulching in crops including vegetable crops. For example.,m Karave *et al*.,2006 reported that no .of leaves per plant of garlic was significantly effected with different rates of mulching and treatment (9 t ha^{-1}) showed significant increase in no. of leaves per plant as compared to other treatments.

Table 2. Number of leaves per garlic plant as influenced by mulching

Treatments Mulching (t ha^{-1})	30 DAP	40DAP	50DAP	60DAP
0	2.64	4.81	6.62	12.54
5	2.70	4.74	6.70	12.34
7	2.69	4.75	6.86	13.48
9	2.77	4.88	6.87	14.20
LSD	0.1298 S	0.2743 S	0.3339 S	1.1126 S

Source = Karaye *et al*., 2006

Plowing / Tillage Practices.

Plowing/tillage is essentially required for best crop growth and quality of production. For this purposes tillage is given with the help of ploughs at proper times. Soil should not be too dry or too wet for plowing. As dry soil when plowed becomes powdery and wet soil becomes compacted or puddle and both are not suitable for growing of crops .Ploughing soil with help of steep mould plough is effective. Plowed soil should become a reservoir of rain water and should support good crop production. The purpose of ploughing is as follows;

- ❐ To produce a rough, cloddy surface that will increase moisture absorption and reduce runoff, as well as erosion from wind and water.

- To control/destroy weeds that compete with crop for sunlight, nutrients, and water.
- To destroy or prevent the formation of a hard pan (sole) which can develop after repeated shallow plowing or harrowing. This hard pan can stunt root growth, reduce water storage, and check the capillary rise of water from the subsoil.
- Promotion of bacterial activity by aerating soil, encouraging the decomposition of organic residues and the release of soil nutrients. Afoloyan,2004 reported that different methods of tillage showed different responses on various growth paramaters of Amaranth.

Table 3. Effect of tillage method on the growth of leafy Amaranth (Large Green)

Tillage Method	Leaf area cm^2	No. of leaves per plant	Root depth per plant (cm)	Stem girth (cm)	No. of roots per plant	Plant height (cm)
No Tillage	47.5	15.3	17.1	5.3	24.3	33.4
Slashing	44.3	16.00	17.3	4.00	22.0	28.3
Ploughing	74.4	16.00	17.4	5.00	21.0	29.9
Ploughing +Harrowing	52.2	16.00	17.00	3.9	22.0	25.8
Ploughing +Harrowing +Bedding	58.4	15.00	16.5	5.4	26.0	29.6
LSD (5%)	38.9	ns	ns	ns	ns	ns

Source = Afolayan *et al.*, 2004

Timing of Tillage

Plowing, like planting, is sensitive to moisture and neither should be done when soil is either too wet or dry. In the arid and semi arid tropics, proper moisture conditions are likely to occur only at the beginning of the rainy season and should be done on the same day. If possible, planting should immediately following plowing, with seed rows centered on the furrow slices. A crosswise harrowing will cover seeds and close air spaces, thus creating a dirt mulch and keeping out the drying winds.

Depth of Plowing.

Generally speaking, heavy clay soils should be plowed deeper than light, sandy soils, in order to promote circulation of the air and bacterial activity. Deep plowing on sandy soils, which are naturally porous and open, tends to disconnect the seed bed from the subsoil and speeds soil drying by too free a circulation of air in the soil. In semi-arid climates, the greatest advantage to be gained from deep plowing (5-8 inches) is the development of a comparatively large moisture reservoir.

Seed Bed Preparation.

It is the one of important and basic operation in efficient crop production of crops especially of vegetables crops. In general, smaller seeds require a finer, mellower seed bed than larger seeds. Seeds germinate and plants grow more readily on a reasonably fine, well prepared soil than on a coarse, lumpy one, and thorough preparation reduces the work of planting and caring for the crops. It is possible to over do the preparation of soils. They should be brought to a granular rather than a powder-fine condition for planting. Planting of crops should be done in rows to facilitate inter-tillage and various intercultural operations.

Planting Density

Limited moisture availibilty in dry areas directs the necessity for wider row spacing and lower rates of seeding (by one-half to two-thirds) than are used in moisture abundant areas. The resulting reduced plant population provides more moisture and nutrients per plant and thus enhances the possibility of the crop reaching maturity before the supplies are exhausted. One of such examples has been reported by Babaeian et al., 2012 reported that Higher and lower grain yield of bean (*Phaseolus vulgaris L.*) in different row spacing were obtained from R1 (50 cm) and R3 (30 cm) with mean of 4.10 and 2.34 ton/ha respectively (Table 4). This result showed that increase in row space from 30 to 50 cm increased grain yield of bean about 42.92%.

Table 4: Influence of Row spacing on yield and yield components of common bean

Treatment Row spacing	Grain yield	100 Grain weight	No. of seeds per plant	No. of pods per plant	Stem height (cm)
R1 (50 cm)	4.10	49.70	67.75	23.23	49.00
R2(40 cm)	3.50	44.83	39.67	15.19	44.83
R3(30 cm)	2.54	40.00	23.69	9.01	40.00

Source = Babaeian *et al.*, 2012

Crop Rotation

Crop rotation is the need of agriculture in the present context. Dry farming is most dependent on crop rotation without which it woul be harsh to produce crops in such areas.The following purposes of crop rotation is as follows.

- Success with monoculture is impossible
- Moisture Conservation occurs in crop rotation
- Pest,disease and weed Control is possible in crop rotation

- ❒ Erosion Control is possible
- ❒ Soil fertility and Structure is maintained
- ❒ Distribution of Labor and Risk.

Crop and Variety Selection.

Choice of varieties is important. Varieties which have proven excellent in irrigated or high rainfall areas are generally unsuited for dry land conditions. Many attempts at dry land farming have failed, largely due to lack of recognition of the requirements for the variety selection.

Variety requirements for dry farming:

- ❒ Dwarf varieties with limited leaf surface and fewer number of stomatoes will minimize transpiration.
- ❒ Deep, prolific and efficient root systems enhance moisture utilization.
- ❒ Early and Quick-maturing varieties are important in order that the crop may develop prior to the hottest and driest part of the year and mature before moisture supplies are completely exhausted (Escape mechanisms).
- ❒ Resistant and tolerant crop varieties to rainfed conditions should be For example Arka meghali, pusa dofasli and pusa rituraj are a kind of such varieties.

Conclusion and Future Strategies

The dryland regions of the country has huge potential to produce the vegetables,particularly cucurbitaceous, solanaceous vegetables and spice crops. This region may work as a huge potential to produce several kind of vegetables in mass to meet the increasing demand of fast increasing population of the country. This dream and targets may be achieved by developing and providing reliable scientific approaches, technologies and knowledge to the farmers like to protect / survive their vegetable crops in harsh and hot climatic conditions of the region.

There is desperate need to develop and adopt such kind of vegetable production technologies like bunding, mulching,summer tillages,crop rotations, proper plant spacings ,Use of maximum,Rain water harvesting,conservation approaches and further research is needed to develop varieties which are resistant to water stresses,water use efficiency systems like sprinkler and drip irrigations, ground water treatments should be encouraged in such areas.

The desirable targets of the vegetable production can be achieved by reaching to farmer’s field to understand their problems and to provide the suitable technical support to nullify the same. Further there is urgent need to develop value added production and a local market to sell the farmer’s horticultural produces.

References

Allolli, T.B., Hulihalli, K., and Anthani, S.I. 2008. Influence of in- situ Moisture Conservation practices on the performance of Dry land Chilli. *Karnataka J. Agric. Sci.* **21**(2): 253-255.

Afolayan. S.O.,Babalola.S.,Igbeka.J.C.2004. Effect of tillage on soil physical properties,growth and yield of Amaranth. *African crop science journal.* **12**(2): 141-151.

Arun Katyayan. 2009. Fundamentals of Agriculture. *Kushal Publications and Distributors Varanasi.* **1**:43-44.

Babaeian, M., Javaheri M., and Asgharzade .A., 2012. Effect of row spacing and sowing date on yield and yield components of common bean (*Phaseolus vulgaris L.*). *African Journal of Microbiology Research* Vol. **6**(20), pp. 4340-4343.

Birkas M, Jolankai M, Gyuricza C and Percze A. 2004. Tillage effects on compaction, earthworms and other soil quality indicators in Hungary. *Soil and Tillage Research* **78**: 185 96.

Bodnar JL, B Schumacher, S Uyenaka (1998). Garlic production in Ontario, Omafra Factsheet, Canada**.** pp.1-8

Chaudhry M R, Malik AA, Sidhu M (2008). Mulching Impact on Moisture Conservation, Soil Properties and Plant Growth. *Pakistan J. Water Resourc.,* **8**(1): 1-8.

CRIDA (2009). Annual Report Central Research Institute for Dryland Agriculture, *Indian Council of Agricultural Research, New Delhi.*

Dass, H.C. (1989). In: proc. Citrus Shows Cum - Seminar, R.F Research station, Abhor, January 6-7: 12-16.

Ibrahim AI (1994). Effect of grass mulch and plant spacing on growth and yield of garlic (*Allium sativum* L.) Unpublished B. Sc. Project, Department of Agronomy, ABU Zaria.

John T (2000). The physical properties of mulches contribution to weed suppression. ARS Publication, *USDA Agricultural Research.* USA. pp. 1-2.

Karaye, A.K., and Yakubu, A.I. 2006. Influence of intra-row spacing and mulching on weed growth and bulb yield of garlic (Allium sativum L.) in Sokoto, Nigeria. *African Journal of Biotechnology* **5**(3), pp. 260-264.

Khan I, Zubair A, Malik BA (1988). Various seed rates affect yield and yield components of Mash. *Pakistan J. Agri. Res.*, **9**: 16

Meena, S.R., More, T.A., Singh, D., and Singh, I.S. 2009. Arid Vegetable Production potential and income Generation. *Indian Res. J Ext. Edu.* **9**(2): 72-75.

Ndubuisi MC (2009). Physical Properties of an Ultisol Under Plastic Film and No-Mulches and their Effect on the Yield of Maize. *J. Am. Sci*., **5**(5): 25-30.

Nkongolo NV, Yamada M, Nakagawa I (2007). Spatial variability selected soil physical properties and root growth of sweet corn. *J.Environ. Mon. Rest.* **3**(1): 276-285.

Panda.B.districts of Orissa.*Journal of Rural development* **26**(2):189-206.

Poonia.T.C.,Singh,G.D.2005.Impact of vegetative barriers on soil and water conservation and production of kharif crops on marginal lands affected by wind. *Annuals of Arid Zone.* **44**(1): 199-201.

Ram, M., and Daweri. M.R. 2010. Management of Natural resources for Sustainable Dry land Agriculture. *International journal of Agriculture and Crop sciences*. **2**(1): 9-25.

Reddy, N.N., Reddy, M.J.C., Reddy, M.V., Reddy, Y.V.R., and Singh, H.P. 2002. Role of Horticultural Crops in Watershed Development Programmes Under Semi-Arid Sub Tropical Dryland Conditions of Western India. **12th ISCO Conference Beijing**.*Central Research Institute for Dryland Agriculture Santoshnagar, Saidabad (P.O.), Hyderabad*-500 059, India.

Shahidul. H.M., Rezaul. I.M.,Abdul Karim M.,and Abdul.Halim.K.M.2003.Efect of natural and synthetic mulches on garlic (Allium sativum .L). *Asian Journal of Plant Sciences,* **2**(1): 83-89.

Sharma, R.Bharat., .Rao, K.V.,Vittal.,K.P.R.,and Amarsingh,U.A.2005. Realising the potential of Rainfed Agriculture in india. *Central Research Institute for Dryland Agriculture, Hyderabad, India.*and *International Water Management Institute, Asia Regional Office, New Delhi, India :* 1-19.

Singh ,Guriqbal., Sekhon H.S.,Singh,Gurdeep.,Brar,J.S., Bains ,T.S., and Shanmugasundaram, S 2011. Effect of plant density on growth and yield of Mungbean (Vigna radiate, L.) Genotypes under different environments in India and Taiwan. *International journal of agricultural research* **6**(7).573-583.

Singh AK, Singh S, Appa Rao VV, Meshram DT (2008). Effect of mulching on soil properties, growth and yield of 'NA7' Aonla (*Emblica officinalis)* in semi-arid ecosystem. *Indian J. Agric. Sci*., **78**(2): 193-197.

Steele CC, Grabau LJ (1997). Planting dates for early maturing Soybean (*Glycine max L.*) Cultivars. *Agron. J*., **89**: 449–53.

Subrahmaniyan K, Kalaiselvan P, Balasubramanian TN, Zhou W (2008). Soil Properties and Yield of Groundnut associated with Herbicides, Plant Geometry, and Plastic Mulch. Comm. *Soil Sci.Plant Anal*., **39**(7/8): 1206-1234.

Umar MS, CO Muoneke, MD Magaji (2000). Effect of intra-row spacing and mulching materials on growth and yield of onion (*Allium cepa* L.). *Nigeria Journal of Agriculture and Environment.* **1**(2).

Venkateswarlu, B. and Shankar, A.K. (2009). Climate change and agriculture adaptation and mitigation strategies. *Indian Journal of Agronomy***. 54** : 226-230.

Randy Creswall and DR. Franklin W. Martin Dryland Farming 1998: Crops and Techniques for arid regions Published by *ECHO Staff.*