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# STUDIES ON THE MASHBEAN (*VIGNA MUNGO*) IN RAINFED AGRO-ECOSYSTEM

**MUHAMMAD ASLAM, N.I. HASHMI AND ALAN. R.A. STAPLETON***

*Wheat Programme*
*National Agricultural Research Centre, Islamabad, Pakistan.*

**Abstract**

On a loam soil having pH of 8.0., water requirements, dry matter accumulation, yield performance, water use efficiency (WUE) and economics of mashbean (*Vigna mungo*) were studied during kharif 1992 and 1993, at the National Agricultural Research Centre, Islamabad. Water requirement for mashbean growth cycle varied depending upon season, potential evapotranspiration (ETo) and crop coefficients. It ranged from 332.8 mm to 357.8 mm from sowing upto its maturity during 1992 and 1993, respectively. Overall under agro-ecosystem of Islamabad, rainfall was surplus than water requirements of mashbean. Dry matter (DM) accumulation vs days after planting (DAP), showed sigmoid response curve. Maximum crop growth rates were 15.8 g $m^{-2}$ $d^{-1}$ from 50 DAP to 79 DAP during 1992 and 21.4 g $m^{-2}$ $d^{-1}$ from 58 DAP to 77 DAP during 1993. Mashbean produced seed yield of 1147 kg $ha^{-1}$ (Average of two seasons). Mean water use effeciency of both seasons was 3.4 kg/ha/mm. Net monetary benefits of Rs. 5788 per hectare could be obtained by sowing mashbean under rainfed ecology.

## Introduction

Pakistan has 17 agro-ecological zones and in eleven of these rainfed agriculture prevails (Rafiq, 1976). In Punjab 13.5 million hectares are designated as cropped area, of which 2.3 million hectares (17.4%) is rainfed (Ahmad, 1988). The focus of present study was the rainfed (barani) areas of northern Punjab (Pothwar region). The average rainfall distribution varies considerably from north-east to the south-west parts of the zone and has been classified into three categories as sub-humid, semiarid and arid areas. This zone is part of the great Indogangetic synclinorium separated from it and elevated at the end of tertiary period. The surface soil materials are: loess deposits, residual mental on sandstones and shale bedrocks. Soils are generally medium textured and are low in natural fertility. Nitrogen, organic matter and phosphorus are deficient, however, potash level is adequate. The soils have pH of 7.5 to 8.5 (Ahmad *et al.*, 1986). The barani soils developed from loess are subjected to sheet and gully erosion which is intensified with the commencement of monsoon rains due to the fallow system, where the absence of vegetation makes the soil susceptible to erosion. Ahmad *et al.*, (1990) reported annual soil loss of 17-41 t $ha^{-1}$ due to fallow compared to 9-26 t $ha^{-1}$ when the land was under a crop. They also found that in this region cropped cover reduced the annual surface run off by 10-18% and reduced soil loss by 50%.

*Consultant ARP-II, National Agricultural Research Centre, Islamabad.

Supple *et al.*, (1985) and Byerlee *et al.*, (1992) found that cropping intensity in these areas were low and increasing it will improve productivity. Main summer (kharif) crops are maize, sorghurn, millet and groundnut whereas wheat is major winter (rabi) crop. In these areas cropping system is mainly dependent on land type and amount of rainfall. At present, the inclusion of leguminous crops in rainfed cropping systems is minimal. The potential for reducing fallow land with leguminous crops is prevailing considerably high (Byerlee *et al.*, 1992). The objectives of the present studies were to evaluate the environmental, agronomic and economic feasibility of mashbean in rainfed agro-ecosystem. This will provide benchmark information regarding inclusion of mashbean crop in existing cropping systems.

## Materials and Methods

The studies were conducted at the National Agricultural Research Centre, Islamabad (long. 73°08 E, lat. 33°42 N and altitude 510 m) under rainfed conditions. The soil series of the site was described as Shujabad loam. The soil pH was 8.0 with loam texture and bulk density was 1.6 at a depth of 00-30 cm. During kharif 1992 and 1993 mashbean variety "Mash-9001" was sown on the same site with similar management practices. Four plots of 5 m in width and 10 m in length were laid out. The field was disk ploughed, followed by a cultivator and a planking. Fertilizer was applied @ 20 kg $ha^{-1}$ N and 50 kg $ha^{-1}$ P and incorporated into the soil using one cultivator, followed by planking during seedbed preparation. The cultivar Mash-9001 was sown on 20th and 18th July during 1992 and 1993, respectively with single row coulter drill. Seed rate of 18 kg $ha^{-1}$ was used. The row to row distance was kept at 30 cm. Crop was harvested at physiological maturity. All plots were harvested by hand, sun dried and threshed manually.

For estimating dry matter (DM) accumulation, plant samples were harvested as close to the ground as possible from one meter square area. Harvested material was weighed using triple beam balance, placed in a paper bag, and oven-dried at 70° C until achieving constant weight. Mean crop growth rate was calculated as suggested by Gardner *et al.*, (1985). Means regarding accumulation of DM versus days after planting (DAP) were plotted in a spline way using "Slide Write" a computer graphic package. Regression analysis of DM over DAP was carried out by fitting quadratic function ignoring replications using "Minitab 7.1" computer package. To fit quadratic function of data points, multiple regression equation ($Y = a + b_1x + b_2 x^2$) was used with two independent variables of which the second variable was substitutd by the square of the first variable.

The procedures to estimate water requirements under rainfed environments were adopted from FAO (Anon., 1986), Doorenbos & Pruitt (1977). Agroclimatic data were obtained from Water Resources Research Institute, NARC, Islamabad. Potential evapotranspiration (ETo) was calculated on a computer model P-Graph. This model performed calculations on the basis of Penman (1948) equation for a given environment using local weather parameters. The crop coefficient (Kc) values under local climatic conditions were estimated. To plot crop coefficient (kc) curve, mashbean growing period was divided into 4 growth stages named as initial stage, crop development stage, mid season and late season stages. The length of these stages were specified as 15/25/35/20 (95) days as described by Doorenbos & Pruitt (1977). Data were contrived into 10 day period (Dekad) as suggested by WMO (Anon., 1966) and Doorenbos & Pruitt (1977). The water requirements were calculated by multiplying the ETo for a given dekad by the Kc for the same dekad. The available water was expressed by subtracting the water requirements from amount of actual rainfall during that dekad. It is expressed as surplus when subtracted values were positive, otherwise it was a deficit. Water use efficiency (WUE) was calculated according to Gregory (1991). Soil moisture contents were determined at the harvest of crop according to Atkinson *et al.*, (1958). To separate means, analysis of variance was accomplished by using MSTAT-C.

## Results and Discussion

**Water requirements** of mashbean: Mashbean ***(Vigna mungo)*** variety "Mash-9001" consisted growing cycle of almost 95 days from sowing to maturity during both kharif seasons. Water requirements and kc values of mashbean are given in Tables 1 and 2 for kharif 1992 and 1993, respectively. Rainfall and daily mean temperatures during kharif 1992 remained below the normals whereas it was above normals during kharif 1993 (Anon., 1992). Mashbean emergence (100 %) was completed in 4 days after planting during both seasons. Crop coefficients were low for initial period than later period. Data also indicated that during initial growth stages rainfall was surplus than water required by the crop during both seasons. However, kc values were high and rainfall was deficient than the water required by the crop on few later growth stages of mashbean (Tables 1 & 2). The deficit of water was more pronounced on second and third dekad of August and September during kharif, 1992. This season, on later stages of growth with an exception of 345.3 mm rainfall was received during first dekad of September and water was surplus by 295.0 mm than requirement. Total potential evapotranspiration remained substantialy low during 1992 (431.8 mm) than 1993 (466.1 mm). Total water requirement for Mash-9001 variety was 332.8 mm during kharif 1992 and 357.8 mm during kharif 1993. It showed that overall rainfall was in surplus than water required by the mashbean under rainfed regime of Islamabad during both kharif seasons. The results presented indicate a benchmark information on water requirements to cultivate mashbean under high rainfall situation. However, in other agroecological zones with different rainfall patterns it may be useful to analyse and predict the suitability of mashbean in relation to local agro-ecosystem.

**Dry matter accumulation in** mashbean: For estimating dry matter (DM) accumulation, plant samples could not be harvested in the begining due to wet field conditions. However, biomass harvests were made at stages with 50% of plants with 7 nodes on main stem (34 DAP), flowers begins to appear on 100% plants (50 DAP), flowering completed and almost 2cm pod on upper most node (67 DAP), pods with full size green beans (76 DAP) and physiological maturity (90 DAP) during kharif 1992 and during 1993 at stages when 50% of plants with 7 nodes on main stem (32 DAP), flowers begins to appear on 100% plants (58 DAP), flowering completed and almost 2cm pod on upper most node (68 DAP), pods with full size green beans (77 DAP) and physiological maturity (90 DAP). Response curves of mashbean DM vs DAP for both

**Table 1. Water requirements for mashbean during kharif, 1992.**

| Month | Dekad | Rainfall (mm) | Potential evapotran-spiration (mm) | Crop coeffi-cients (Kc) | Water require-ments (mm) | Water available (S/D)* |
|---|---|---|---|---|---|---|
| July | 3 | 90.8 | 69.3 | 0.40 | 27.7 | + 63.1 |
| August | 1 | 128.5 | 58.0 | 0.57 | 33.1 | + 95.4 |
| | 2 | 31.9 | 61.1 | 0.87 | 53.2 | - 21.3 |
| | 3 | 22.4 | 62.2 | 1.05 | 65.3 | - 42.9 |
| September | 1 | 345.3 | 47.9 | 1.05 | 50.3 | + 295.0 |
| | 2 | 13.1 | 47.5 | 1.05 | 49.9 | - 36.8 |
| | 3 | 0.0 | 47.4 | 0.80 | 37.9 | - 37.9 |
| October | 1 | 6.6 | 38.4 | 0.40 | 15.4 | - 8.7 |
| Total | - | 638.6 | 431.8 | - | 332.8 | + 305.8 |

*Surplus or deficit.

seasons showed sigmoid response (Fig.1). It showed maximum increase in DM accumulation from just before flowers begins to appear on 100% plants (almost 50 DAP) upto pod development (soft dough) stage which was almost 77 DAP during kharif 1992. The maximum average crop growth rate of mashbean for this period was 15.8 g $m^{-2}$ $d^{-1}$. During kharif, 1993 highest increase in dry matter accumulation was observed from 58 to 77 DAP and crop phenological stage was almost just before the appearance of flowers upto pod development (soft dough) stage with maximum average crop

**Table 2. Water requirements for mashbean during kharif, 1993.**

| Month | Dekad | Rainfall (mm) | Potential evapotran-spiration (mm) | Crop coeffi-cients (Kc) | Water require-ments (mm) | Water available (S/D)* |
|---|---|---|---|---|---|---|
| July | 3 | 48.5 | 75.0 | 0.40 | 30.0 | + 18.5 |
| August | 1 | 152.4 | 62.4 | 0.55 | 34.3 | + 118.1 |
| | 2 | 33.0 | 68.9 | 0.87 | 59.9 | - 26.9 |
| | 3 | 39.5 | 73.3 | 1.05 | 76.9 | - 37.5 |
| September | 1 | 159.0 | 47.8 | 1.05 | 50.2 | + 108.8 |
| | 2 | 60.7 | 50.6 | 1.05 | 53.1 | + 7.6 |
| | 3 | 9.1 | 45.5 | 0.80 | 36.4 | - 38.7 |
| October | 1 | 0.0 | 42.6 | 0.40 | 17.0 | - 19.2 |
| Total | - | 502.2 | 466.1 | - | 357.8 | + 144.3 |

*Surplus or deficit.

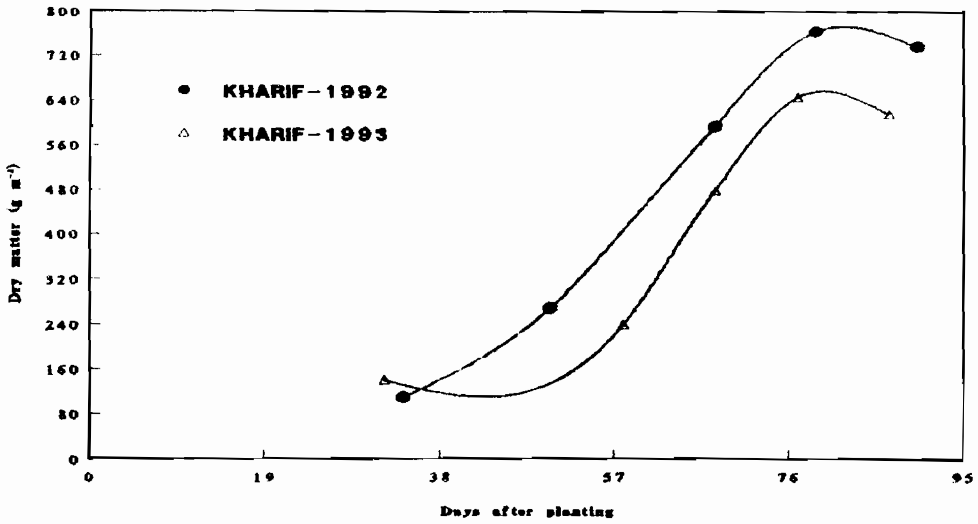


Fig.1. Mashbeen dry matter accumulation patterns during kharif 1992 & 1993.

growth rate of 21.4 g $m^{-2}$ $d^{-1}$. Coefficients estimated for mashbean dry matter vs days after planting from regression analysis are given in Table 3. It showed that coefficient ($b_1$) was positive during both years. The coefficient ($b_2$) was negative during kharif, 1992 whereas, it was positive during kharif, 1993. It may be that during initial period of 20 days water available was surplus than the water requiremets during both the seasons, which may have resulted in uniform crop growth. Whereas in the month of September, rainfall was surplus than the requirements for two dekads during 1993, which may have accelerated crop growth. However, after huge rainfall of 345.3 mm during 1st dekad of September, 1992, it received only 19.7 mm of rains in the remaining period, hence crop growth rates may have lowered down. It is also important to mention that the ETo demand remained low upto last dekad of August during 1992 than 1993. In this period during 1993 from 40 to 60 DAP ETo values were high and available water remained surplus for most of the time than requirements. Water deficit was more pronounced during kharif, 1992 and only 345.3 mm rainfall was received on later stages of growth during first dekad of September in one day. However, more uniform rains and higher ETo in the second and third dekad of September during kharif 1993 than 1992 may have resulted in increase in crop growth rates in later stage.

**Agro-economic performance of mashbean:** Agronomic performance of mashbean variety "Mash-9001" during kharif 1992 and 1993 are presented in Table 4. Non-significant differences in plant height, pods per plant, pod length, 1000 seed weight, seed yield kg $ha^{-1}$ and harvest index were noticed between both season. Seed yield of 1216.3 and 1077.7 kg $ha^{-1}$ was recorded during kharif 1992 and 1993, respectively. However, PARC (Anon., 1990) reported that grain yield of 1821 kg $ha^{-1}$ was obtained when mash-9001 was sown in high rainfall areas. Biological yield of mashbean differed significantly in both seasons and it was 9133.3 kg $ha^{-1}$ and 7115.1 kg $ha^{-1}$ during 1992

**Table 3. Regression analysis parameters for mashbean from DM vs DAP.**

| Kharif | Intercept ($b_o$) | Linear ($b_1$) | Quadratic ($b_2$) | $R^2$ | s |
|---|---|---|---|---|---|
| 1992 | - 453.3 | + 17.70 | - 0.03 | 0.96 | 52.56 |
| 1993 | - 635.2 | + 26.10 | + 0.33 | 0.81 | 106.30 |

and 1993, respectively. Similarly, during kharif 1992, pod yield (2579.2 kg ha$^{-1}$) was significantly higher than that obtained during kharif 1993 (1655.5 kg ha$^{-1}$). This may possibly be due to surplus amount of total available water in 1992 (305.8 mm) than in 1993 (144.3 mm), and high values of potential evapotranspiration in 1993 (466.1 mm) as compared to 1992 (431.8 mm). Water use efficiency was significantly high during kharif 1993 (3.7 kg/ha/mm) than 1992 (3.0 kg/ha/mm). However, the protein percentage was significantly higher in kharif 1992 (27.3) than that of kharif 1993 (24.8). The economic performance (Anon., 1988) showed that the net monetary benefits of Rs.5787.6 could be obtained by sowing mungbean during summer, whereas at present almost 50 % of the land is left fallow (Supple *et al.*, 1985) to conservation moisture.

In a system perspective, the left over soil moisture after kharif crop is important for planting wheat during rabi as it effects its germination. Left over soil moisture available after mashbean harvest was also recorded and it was compared with fallow and different other kharif crops from adjacent plots established for similar study purpose. It showed that volumetric soil moisture (at 0-30 cm) contents of 12.5 and 14.9

**Table 4. Performance of mashbean during kharif 1992 and 1993.**

| Parameters | Kharif 1992 | Kharif 1993 | LSD (0.05) | Means |
|---|---|---|---|---|
| Plant height (cm) | 49.8 | 44.5 NS | 13.1 | 47.1 |
| Pods per plant | 48.5 | 41.0 NS | 14.4 | 44.7 |
| Pod length (cm) | 3.9 | 3.8 NS | 0.3 | 3.8 |
| 1000-seed weight (g) | 42.9 | 43.4 NS | 2.6 | 43.1 |
| Biological yield (kg ha$^{-1}$) | 9133.3 | 7115.1* | 1156.5 | 8124.2 |
| Pod yield (kg ha$^{-1}$) | 2579.2 | 1655.5* | 370.6 | 2117.4 |
| Seed yield (kg ha$^{-1}$) | 1216.3 | 1077.7 NS | 260.6 | 1147.0 |
| Harvest index (%) | 13.3 | 15.4 NS | 3.0 | 14.4 |
| Water Use Efficiency | 3.7 | 3.0** | 0.57 | 3.4 |
| Protein (%) | 27.3 | 24.8* | 1.6 | 26.0 |

*Significant at 0.05 probability, **Significant at 0.05 probability.
NS: Non significant

% were available after mashbean during kharif 1992 and 1993 respectively, and these were at par with fallow (11.6% and 13.2%). However, left over volumetric soil moisture available after mashbean were significantly higher than available after traditionally grown crops such as maize (7.1%), sorghum (8.2%), millet (5.6%) and sunflower (9.8%) during kharif 1992. Whereas during kharif 1993 these values for maize fodder were 13.2%, sorghum (9.2%), sunflower (10.9%) and millet (9.1%) statistically not different from each other but compared to mashbean were significantly low. High soil moisture available in mashbean may be associated with the fact that its crop canopy covered the soil (mulching effect) within short period which minimzed moisture loss through evaporation and transpiration remained as a dominant process during growth cycle. Another advantage of this crop may be its tap root system, which helped to absorb water from the deeper layers of soil than upper. Papenddic & Campbell (1974) also found that moisture loss through evaporation from a fallow were significantly higher than cropped and mulched soil surface.

The results presented indicate that mashbean could be a suitable crop for growing in rainfed agro-ecosystem during summer season in mashbean-wheat cropping system. It will help increase the cropping intensity of the area and also help to conserve soil moisture similar to fallow, required for wheat germination. The added monetary benifits from growing mashbean during summer than a fallow are also considerable. Mashbean sowing in these areas over times will also enhance the soil fertility by fixing nitrogen. Further refinement of the package of technology and effective transfer of technology will help the farmers to adopt mashbean crop in rainfed agro-ecosystem.

**References**

Ahmad, M. 1986. Soils of Pakistan. *In*: Proc.- XII Int. forum on soil taxonomy and agro technology transfer. First volume: technical sessions. Director General, Soil Survey of Pakistan, Multan Road Lahore-18, Pakistan. pp:47-57.

Ahmad, N., J.G. Davide and M.T. Saleem. 1988. Fertility status of soil in dryland areas of Pakistan. *In*: Int. seminar on dryland agriculture in Pakistan. Fauji fertilizer Comp., Pakistan. pp: 22-48.

Ahmad, S., M. Khan and M. Zaheer-ul-Ikram. 1990. Soil and water conservation and integrated land use in Pothwar, Pakistan. *In Soil Physics-Application under stress environments*. Barani Agricultural Research and Development Project (BARD), PARC, Islamabad.

Anonymous. 1966. International meteorological vocabulary, No.182,T.P. 91, World Meteorological Organization.

Anonymous. 1986. Early agro meteorological crop yield assessment. FAO Plant Production and Protection Paper No. 73. Food and Agriculture Organization of the United Nations, Rome. pp.150.

Anonymous. 1988. From agrononic data to farmer recommendations: An Economic training hand book. Economic programme, CIMMYT, Mexico.D.F.

Anonymous. 1990. Annual Report (1989-90), Food Legumes Programme, National Agricultural Research Centre, PARC, Islamabad. pp 148-185.

Anonymous. 1992. Climatic Normals of Pakistan. Computerized Edition. Pakistan Meteorological Department (PMD) Karachi, Pakistan.

Atkinson, H.J., G.R. Giles, A.J. MacLean and J.R. Wright. 1958. *In: Chemical methods of soil analysis*. Contribution No.169. Chemistry Division - Science Services, Canada Department of Agriculture Ottawa, Canada.